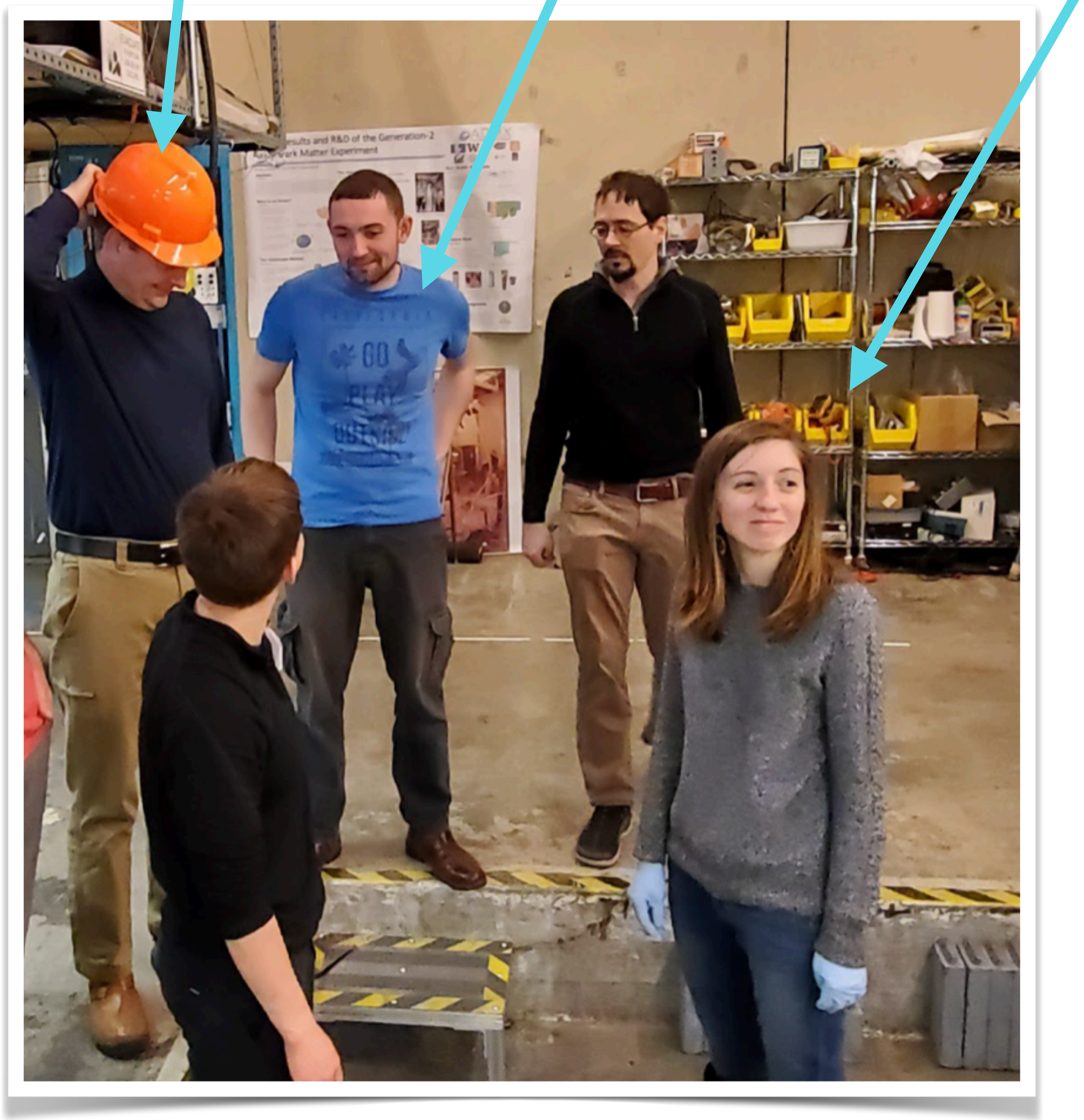
Resonant Feedback

Collaboration Meeting 2020

Chelsea Bartram

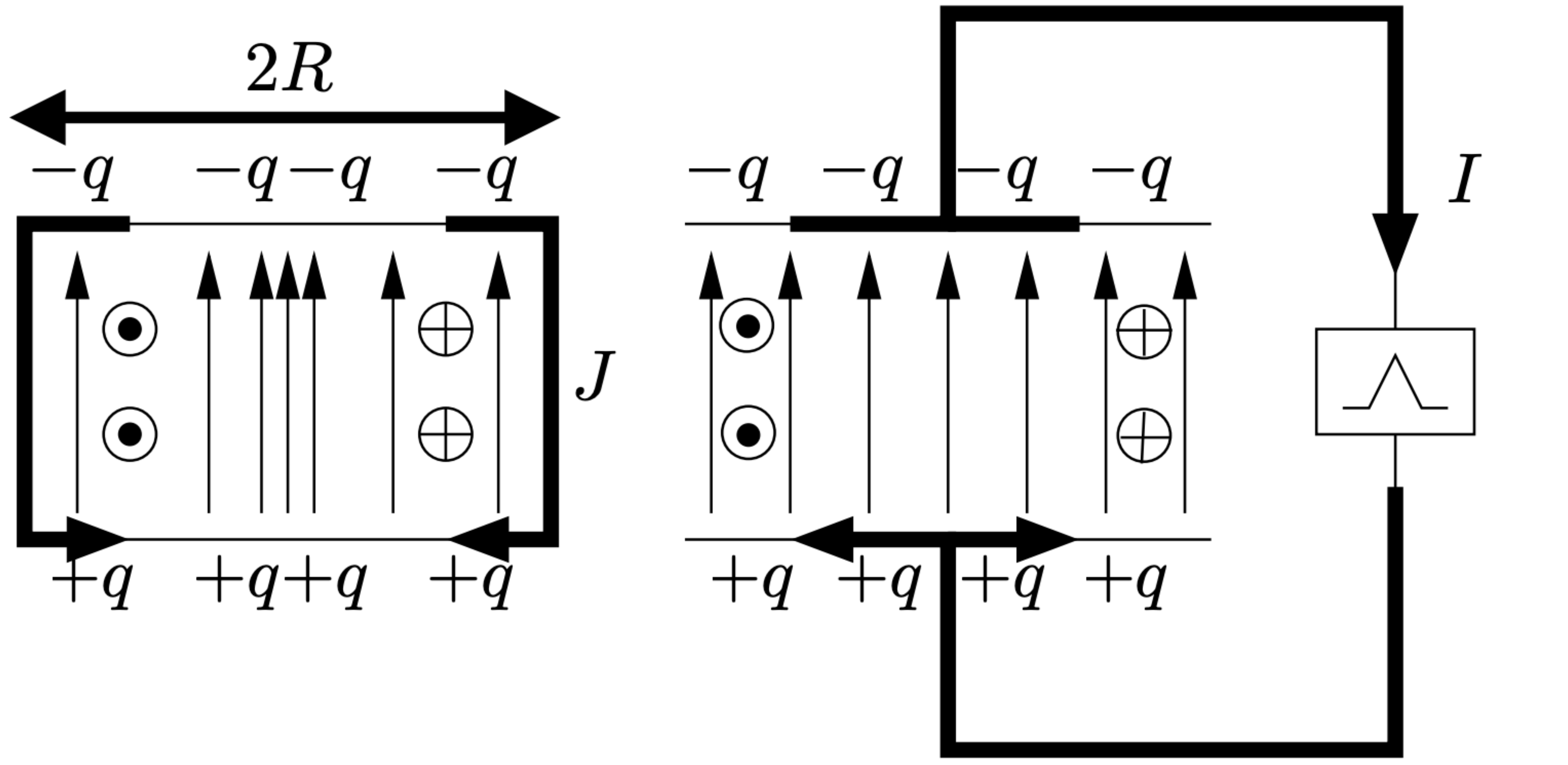
Collaborators:

Ed Daw, Mitch Perry, Chelsea Bartram



Concept:

- Give experimentalist more control over the detector structure
- First demonstrate on a cavity (sidecar, or the prototype stand-in for sidecar)
- FPGA allows creation of digitally generated filters to obtain high-Q
- “Moves the Q out of the cavity”

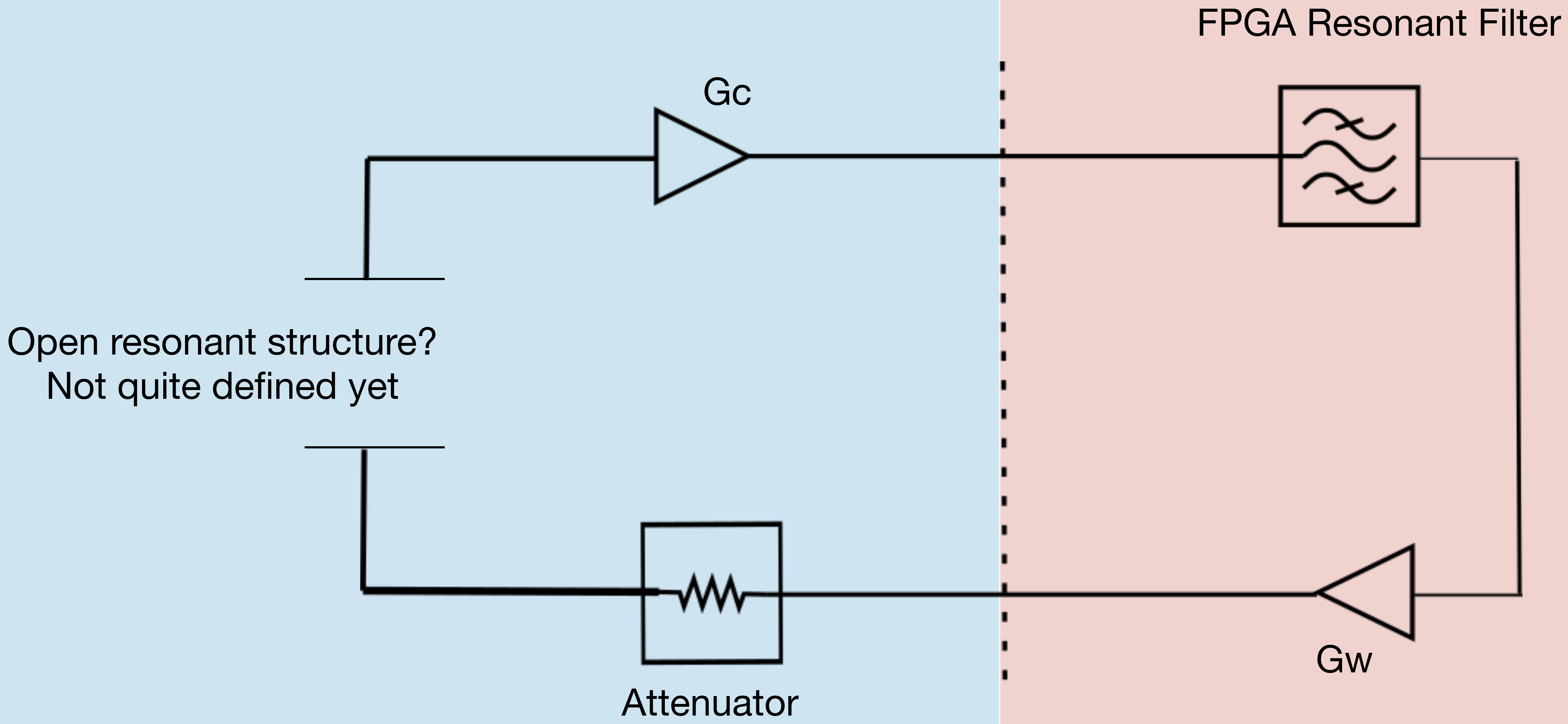


Cavity Resonant feedback

Nuclear Inst. and Methods in Physics Research, A, Volume 921, p. 50-56.

Cold

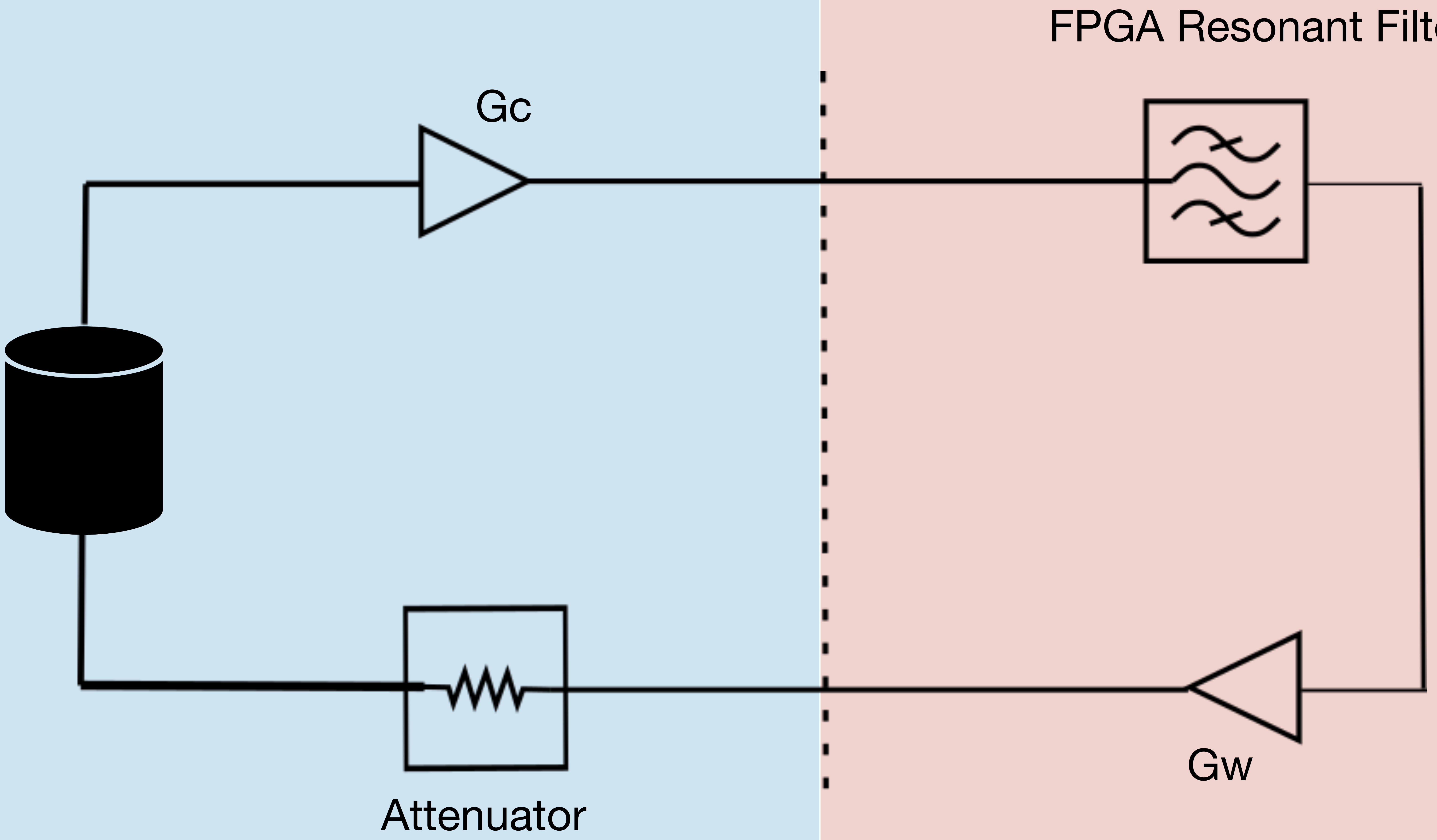
Room Temperature



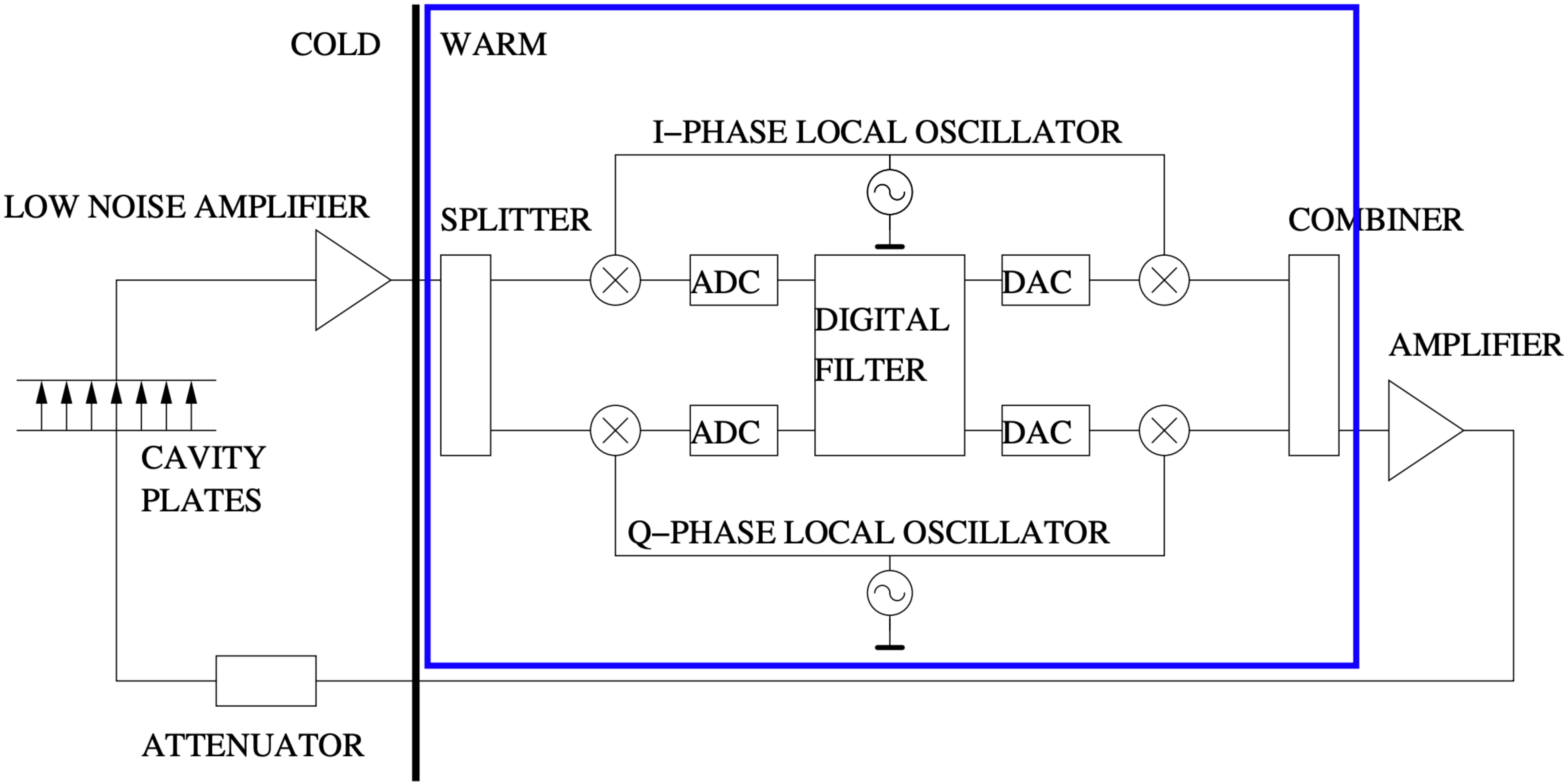
Cold

Room Temperature

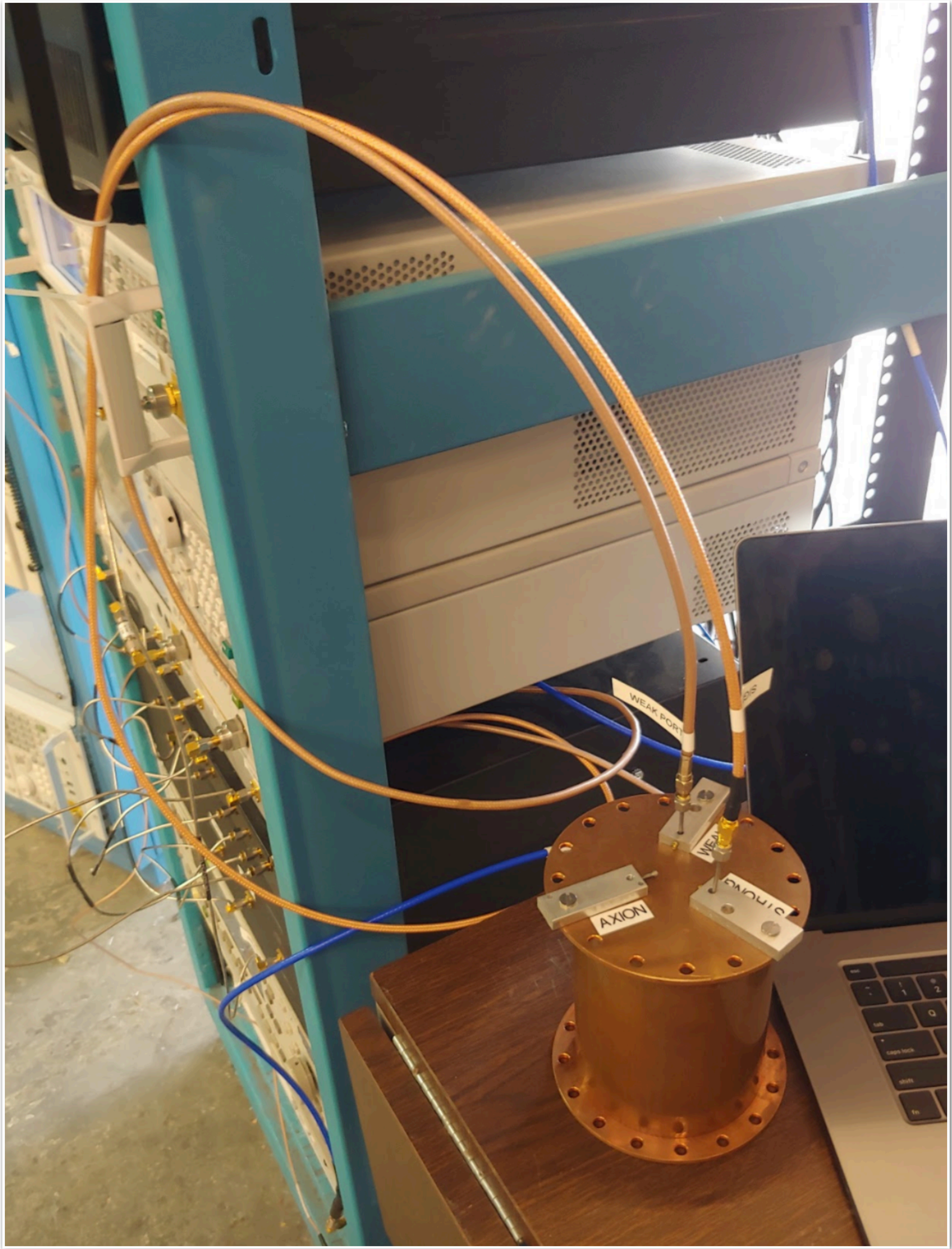
First test the setup with a cavity: Sidecar and prototype warm cavity



Schematic:



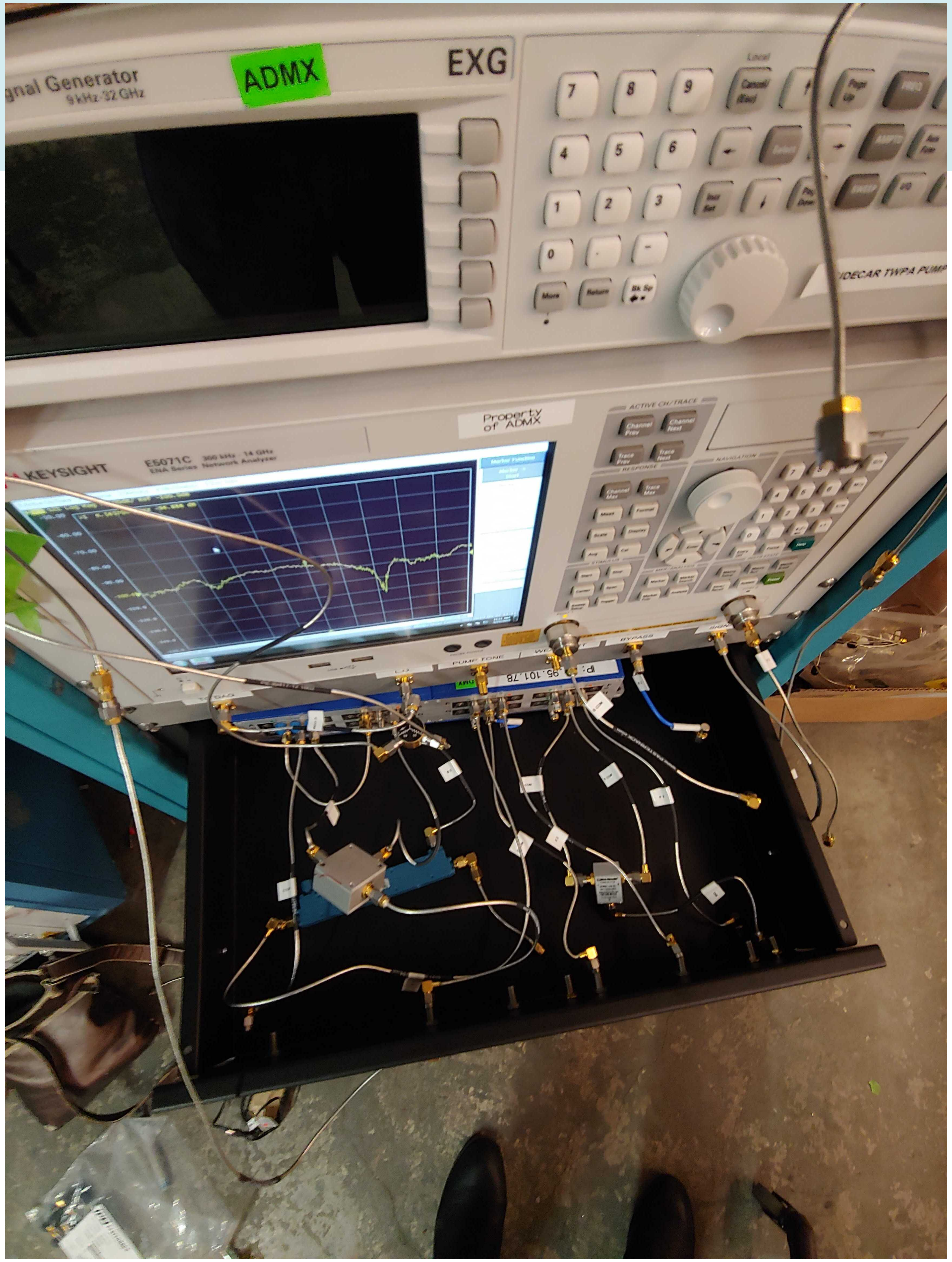
COLD
WARM
I–PHASE LOCAL OSCILLATOR
LOW NOISE AMPLIFIER
SPLITTER
COMBINER
ADC
DAC
DIGITAL
FILTER
AMPLIFIER
ADC
DAC
CAVITY
PLATES
Q–PHASE LOCAL OSCILLATOR
ATTENUATOR

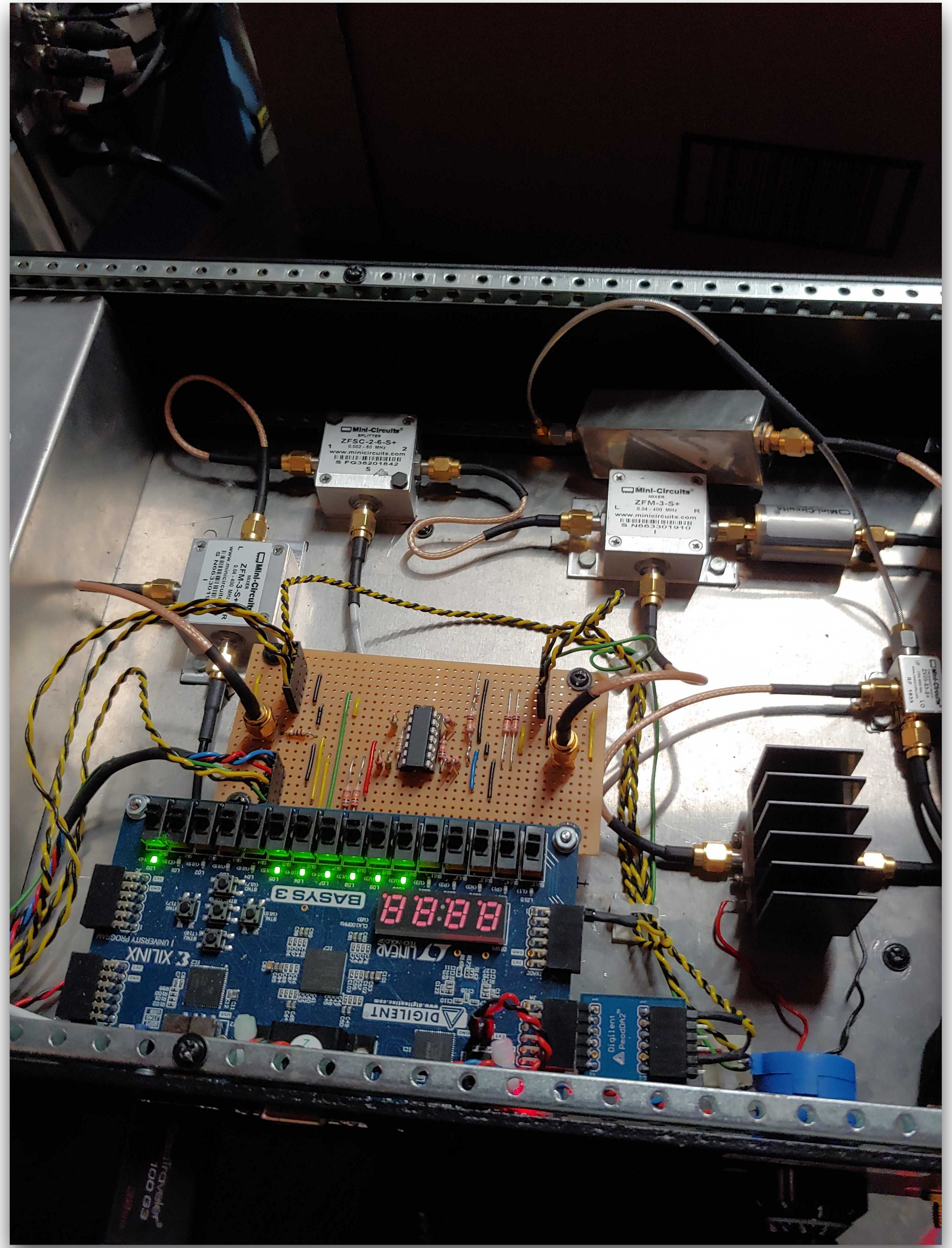

WEAK PORT
AXION


10.95.101.53
EXG
ADMX

Sidecar Wiring

- Built and constructed the sidecar drawer with ability to switch into feedback mode
- Assembled DAQ rack
- Implemented dripline for all instruments
- Set up all necessary LOs and verified correct mixing
- Wrote scripts to coordinate data-taking procedures

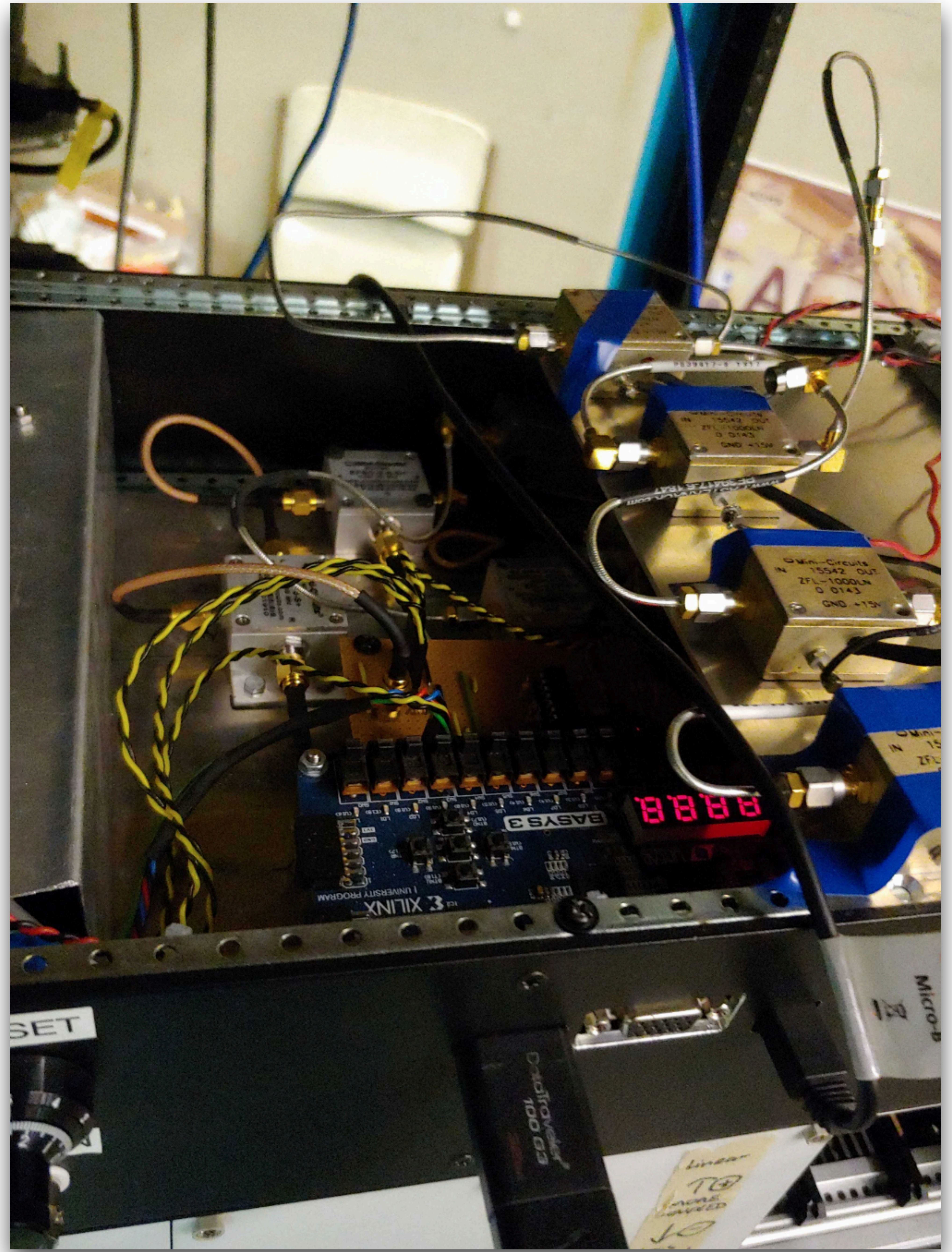




The DIGIBOX

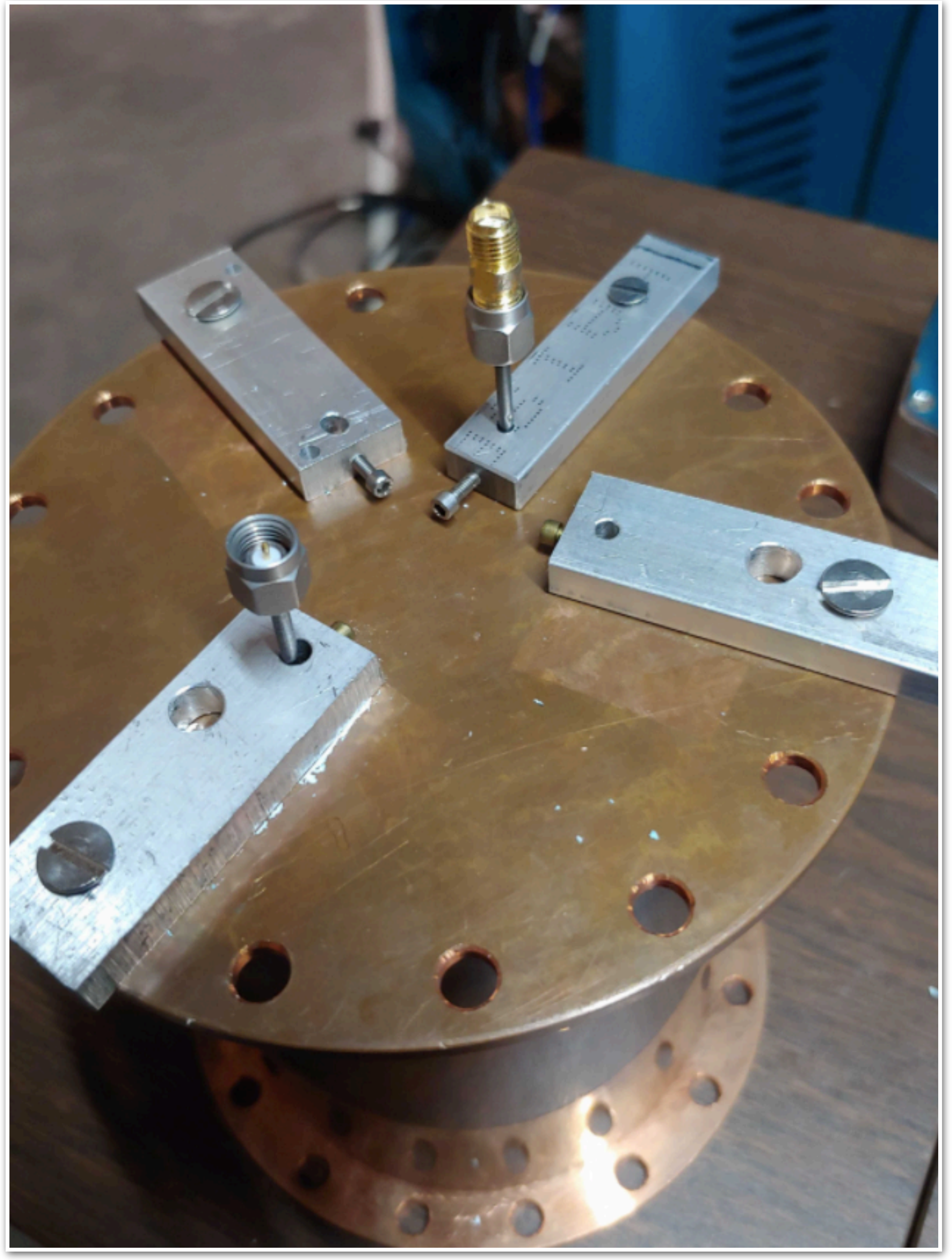
- FPGA programmed by Mitch Perry and Ed Daw using Vivido.
- Multiple filters can be created.
- Multiple mixing stages necessary at the moment due to board capabilities.
- I wrote python interface to issue commands remotely:

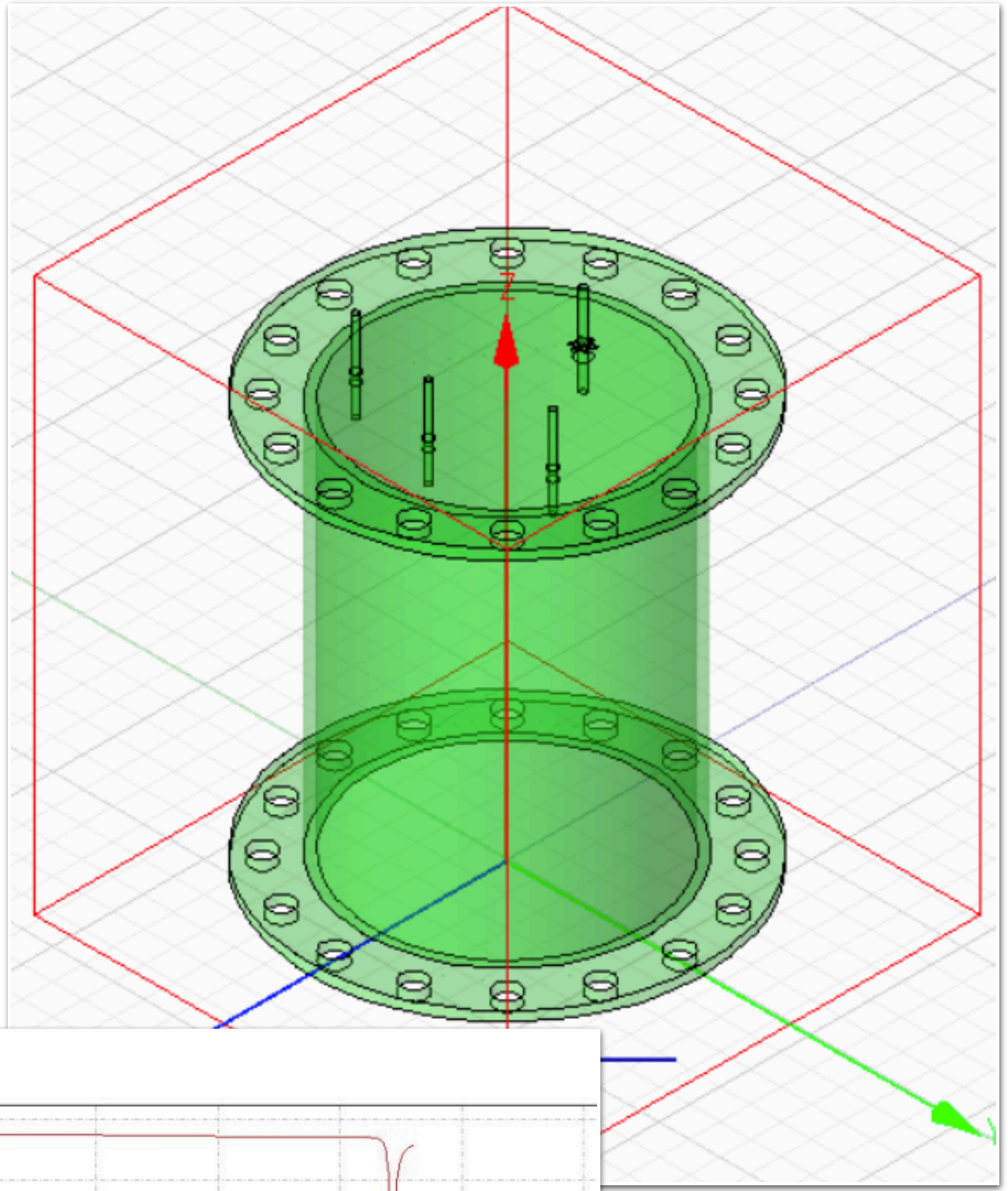
```
cbartram@digibox:~$ sudo python serial_digibox.py
Enter your commands below.
Insert "exit" to leave the application.
>> gain(0)=10


>> freq(0)=15000


>> quality(0)=100


>> 
```

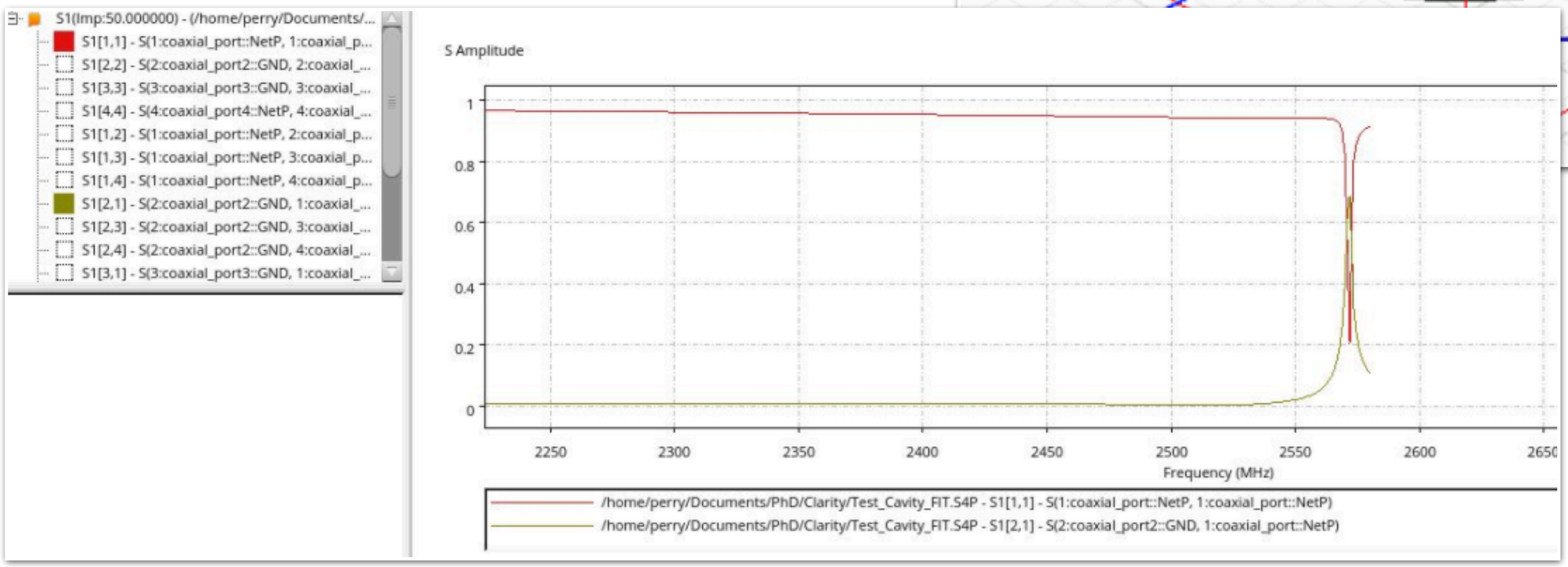


- Very narrow crystal filter to prevent punch-through of LO: caused huge attenuation (see o-scope)
- Needed several amplifiers in series to boost gain

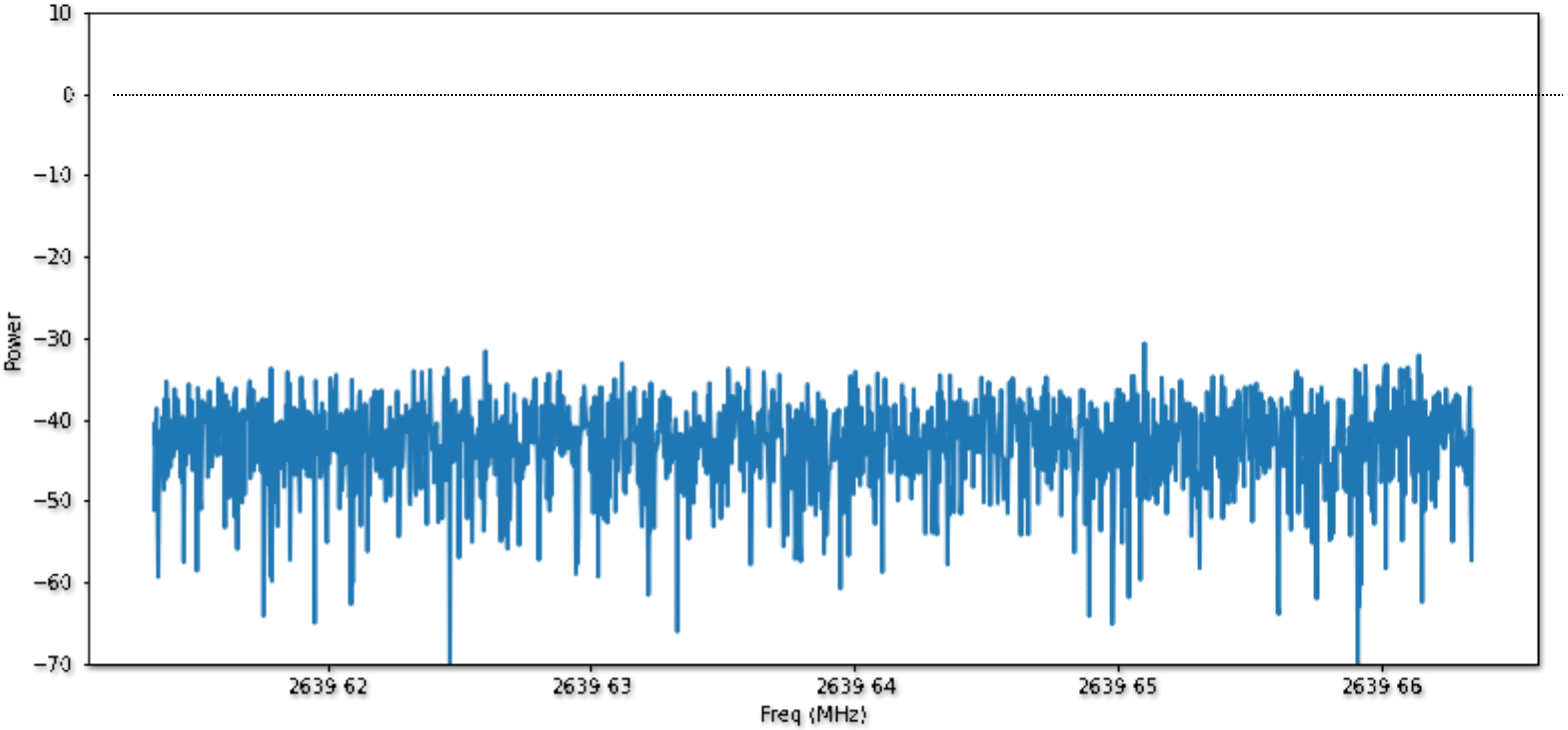
- Machined Cavity to have extra ports
- Simulation with Cadence Clarity (Mitch Perry)
- 2.6 GHz TM010 mode
- Warm test cavity



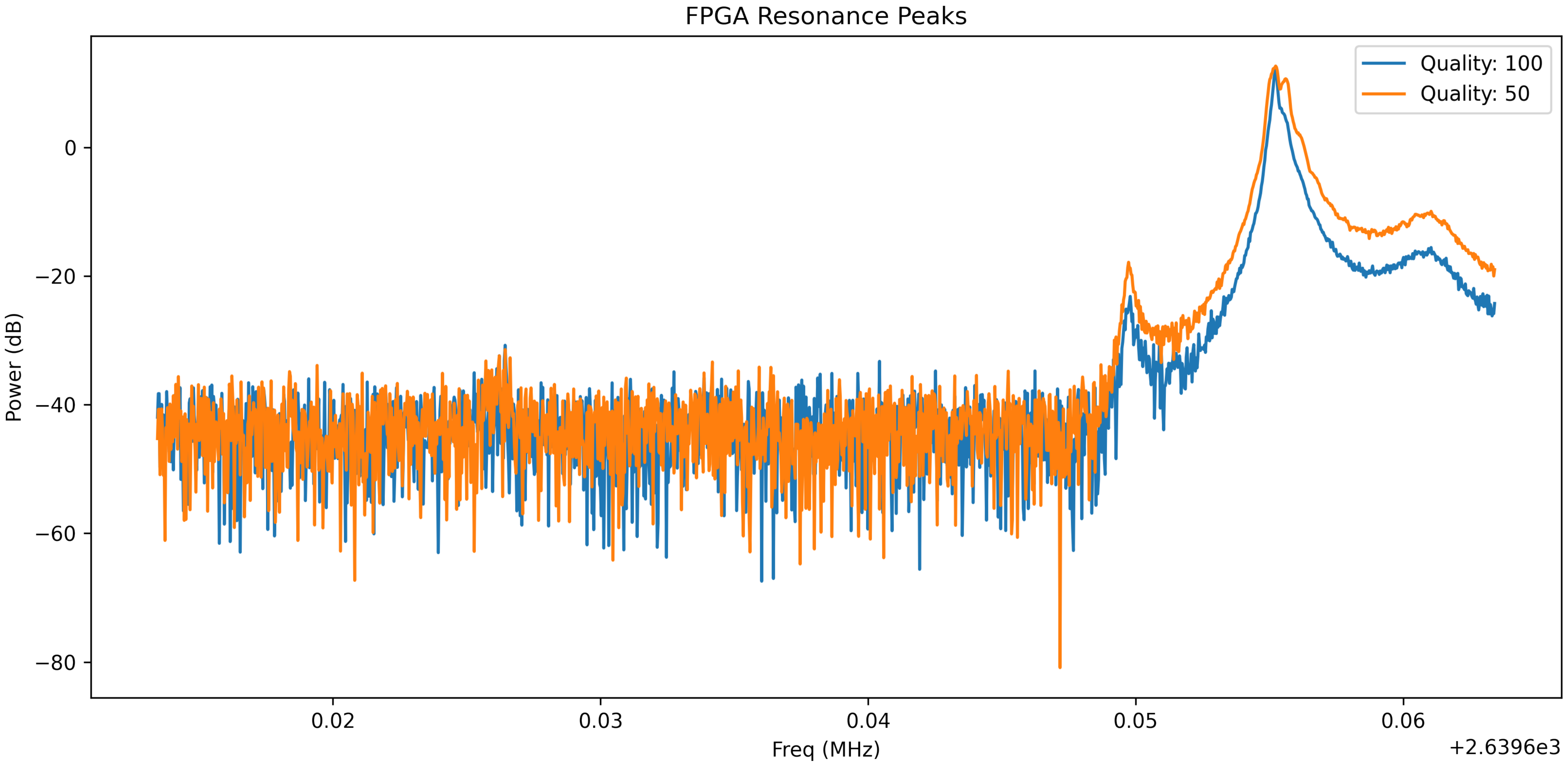




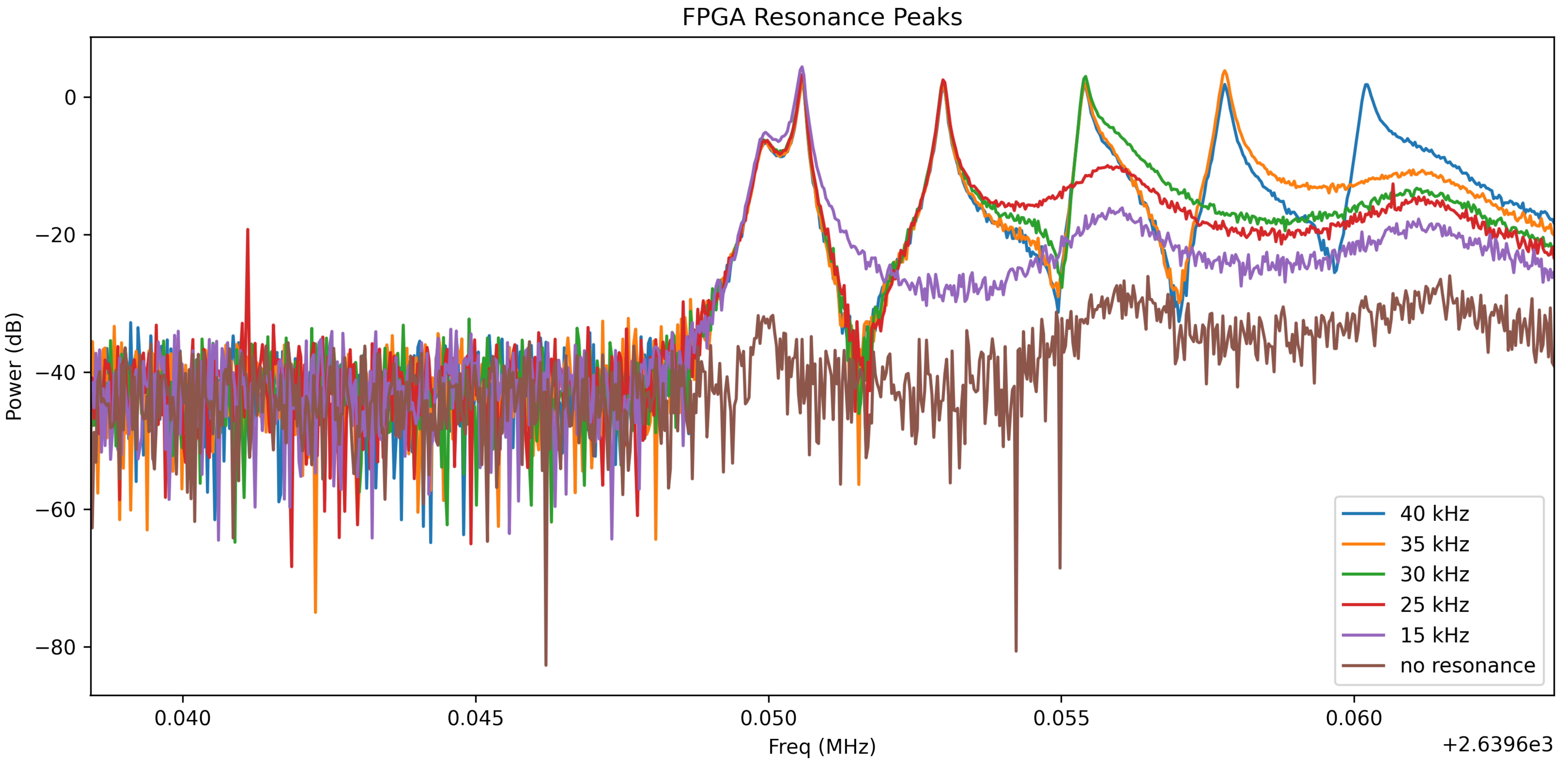
Digitally Adjusting the Gain

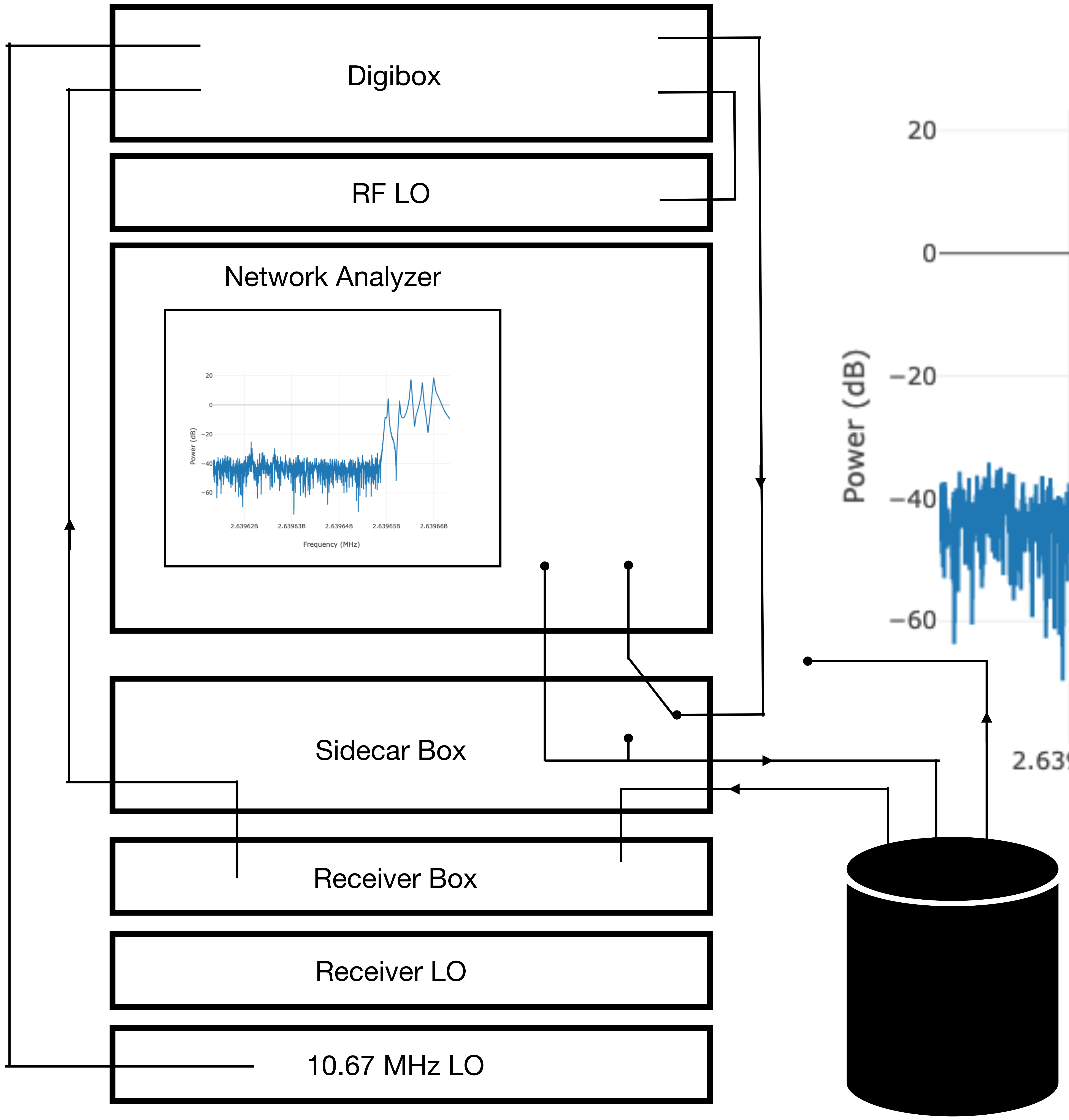


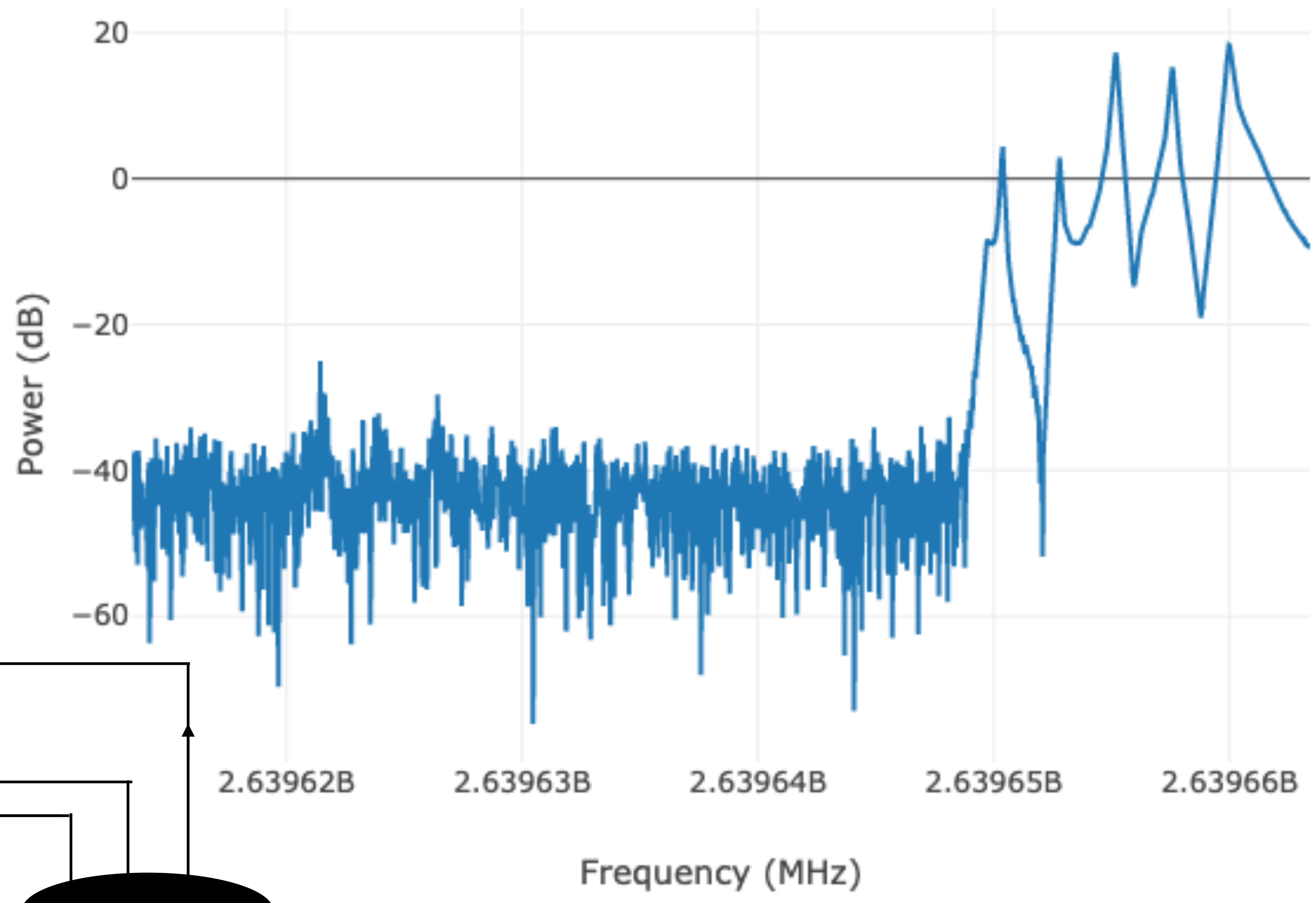
Digitally Adjusting the Quality Factor



Digitally Creating Resonances



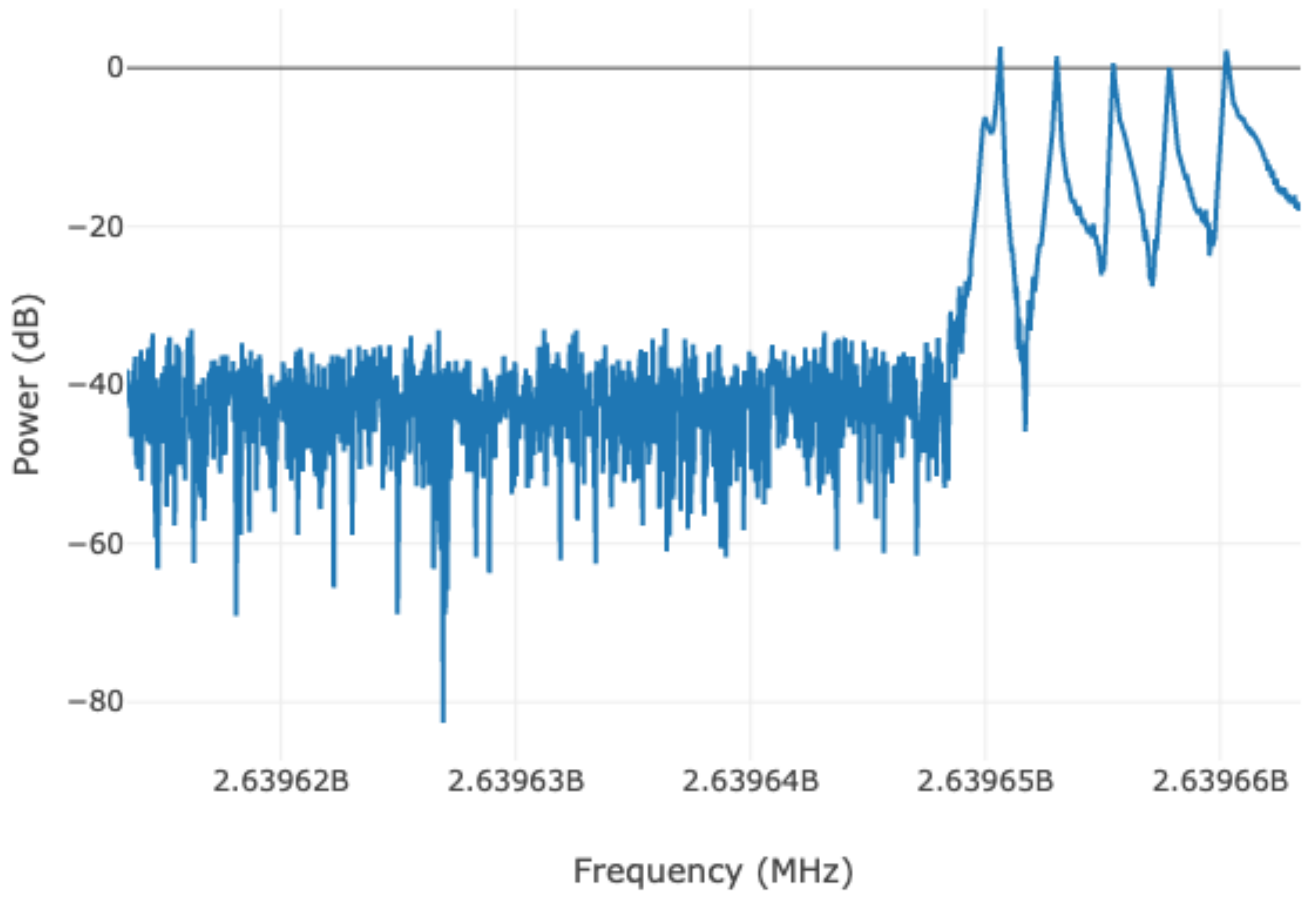




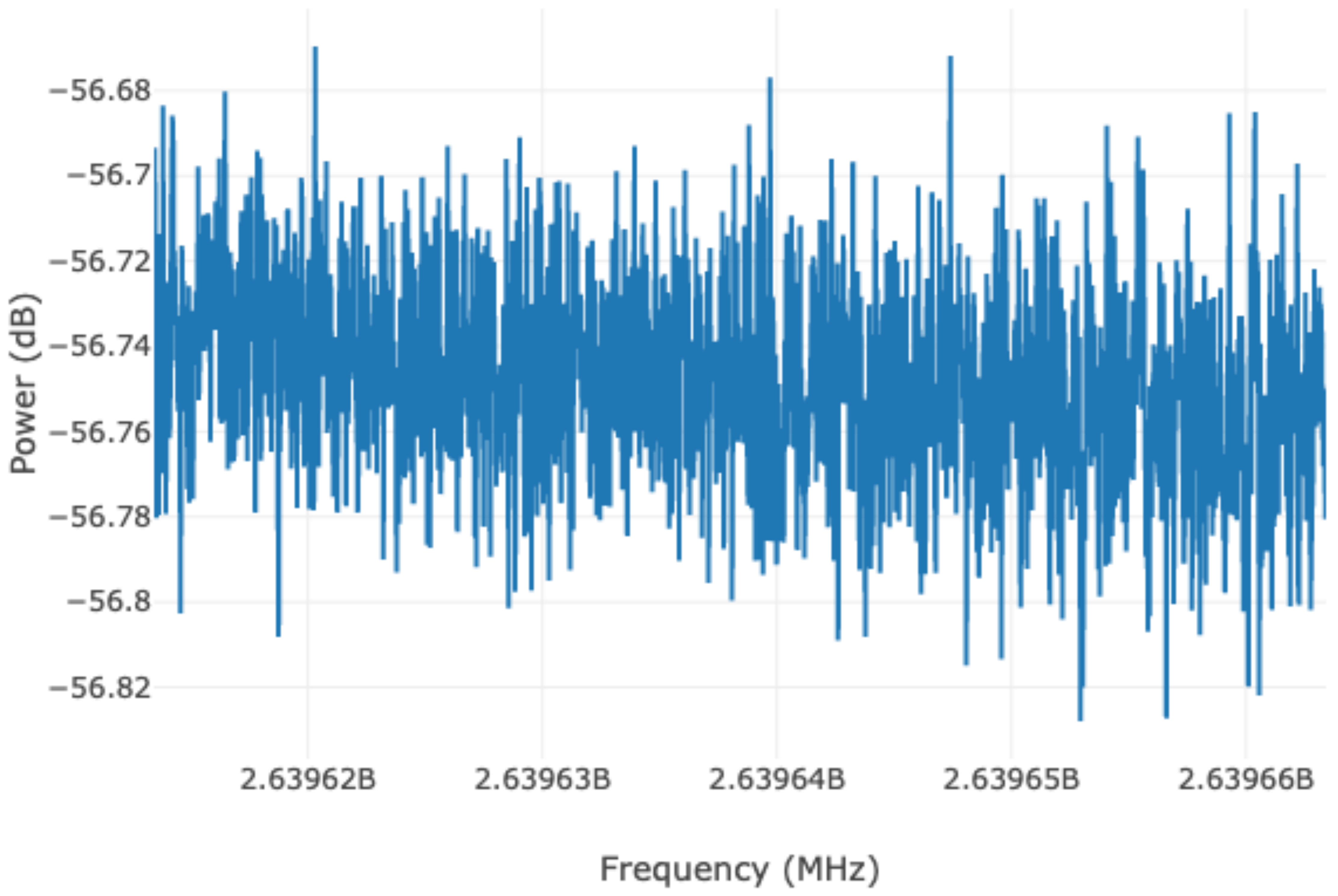
Switch flip command:

set_string_endpoint("sidecar_receiver_switch_state","digitizefeedbackNA")

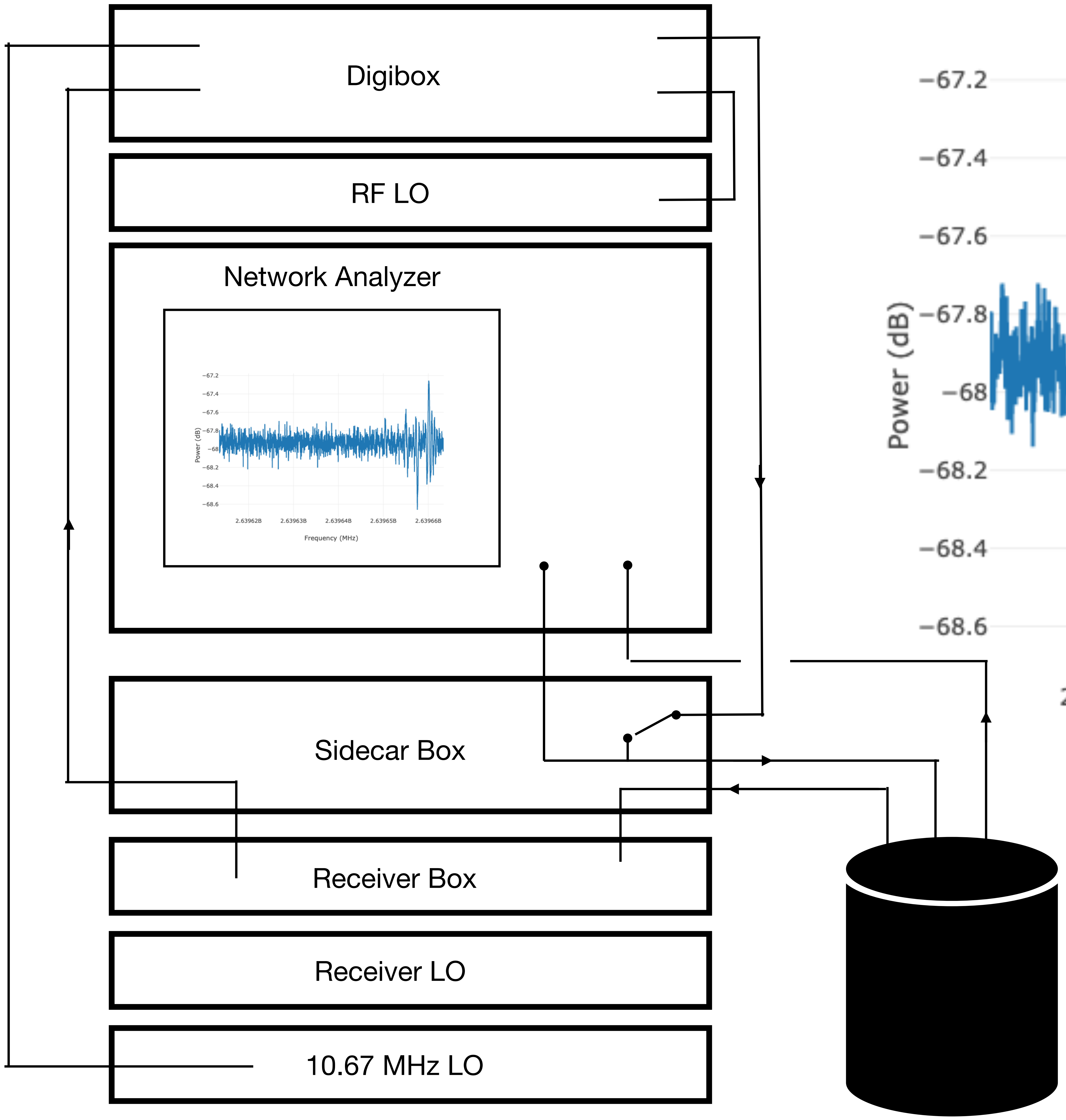
Verifying the open loop gain before it is fed back into the cavity

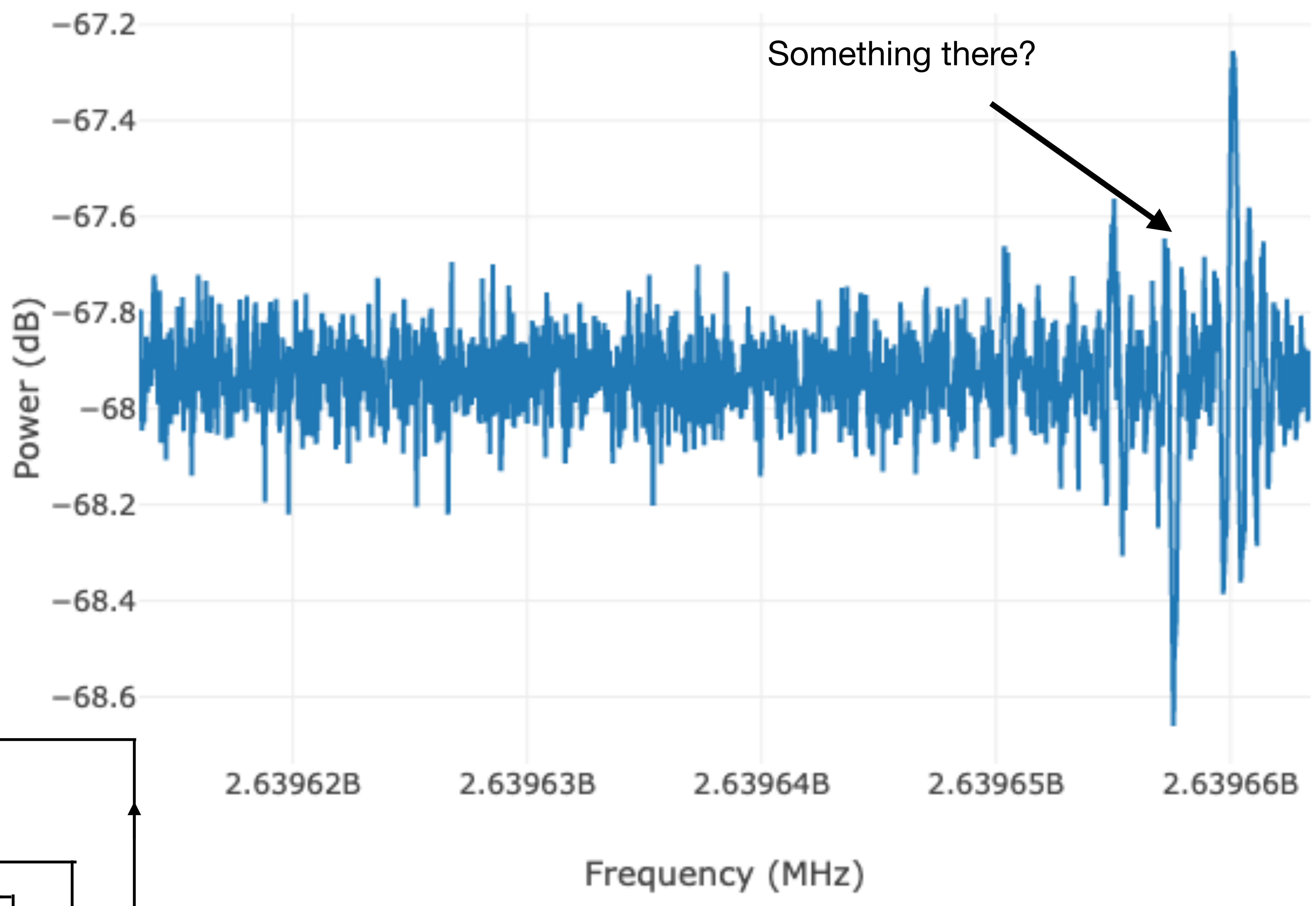


Checking the cavity output
Seems like the gain was a bit too low



Attempt to set the open loop gain of resonances close to one



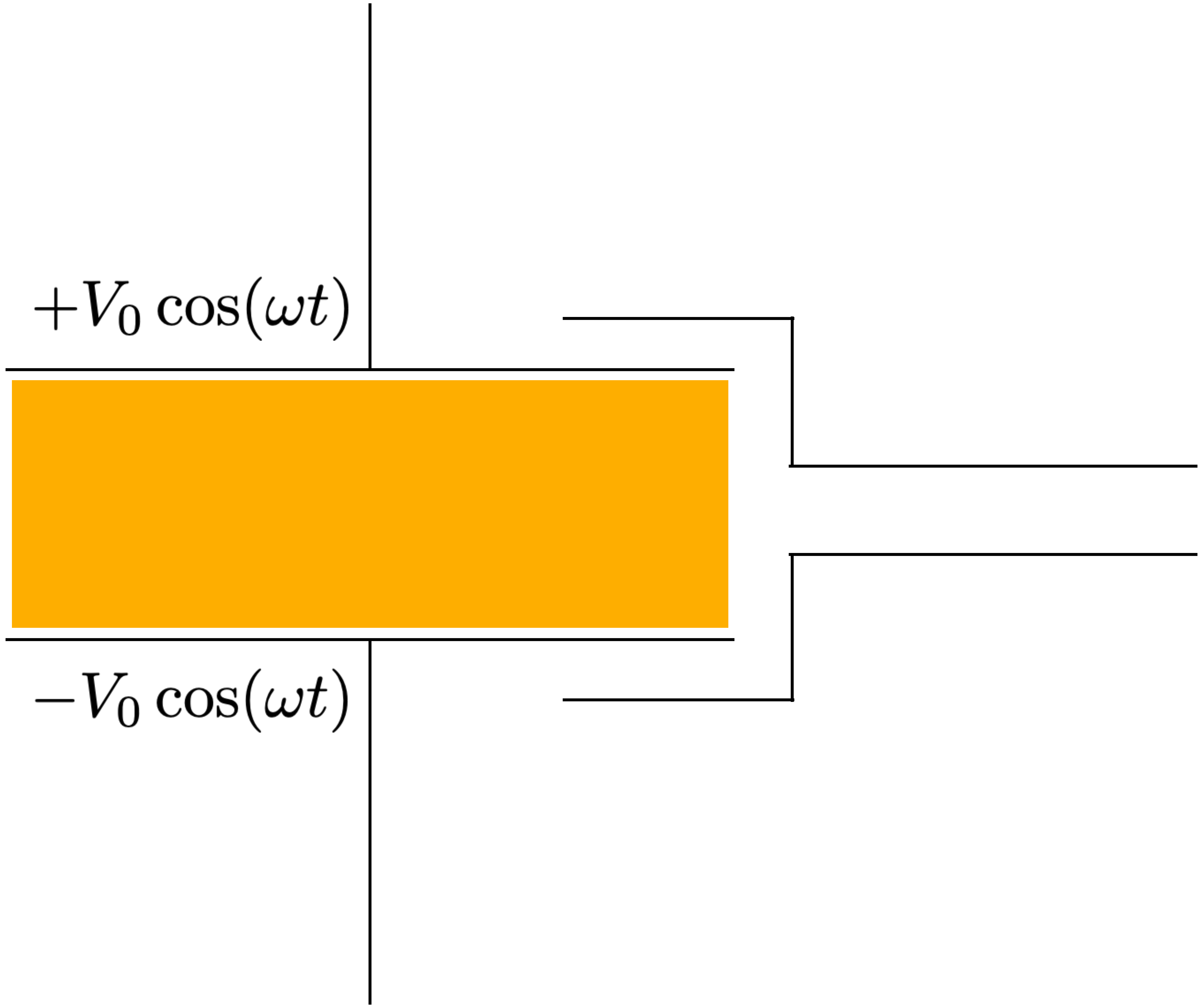


Switch flip command:

set_string_endpoint("sidecar_receiver_switch_state","digitizefeedbackcavity")

Need to account for phase:

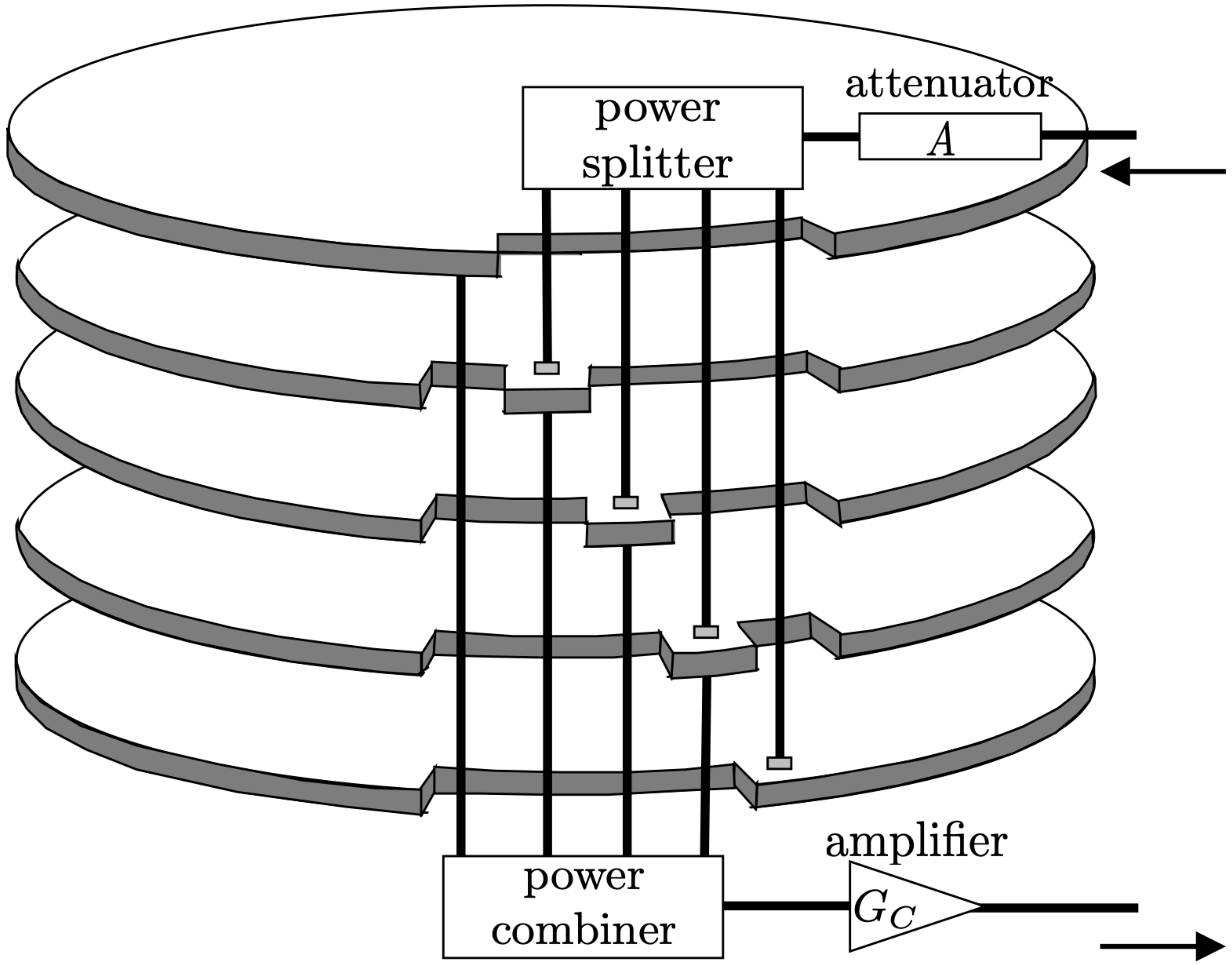
Work in progress...



Differential signal feeds back to control resonant gain

Imbalance in the voltage will cause oscillating potential difference on the sense plates

One possible ‘open’ resonator



Other designs may be possible…

Conclusions

- More freedom in the design of your axion detector
- Could enable broadband capability
- Programmable digital components enable “easy” parallelization and the creation of multiple resonances
- Can try to maximize the form factor
- No tuning rods or other mechanical tuning mechanism