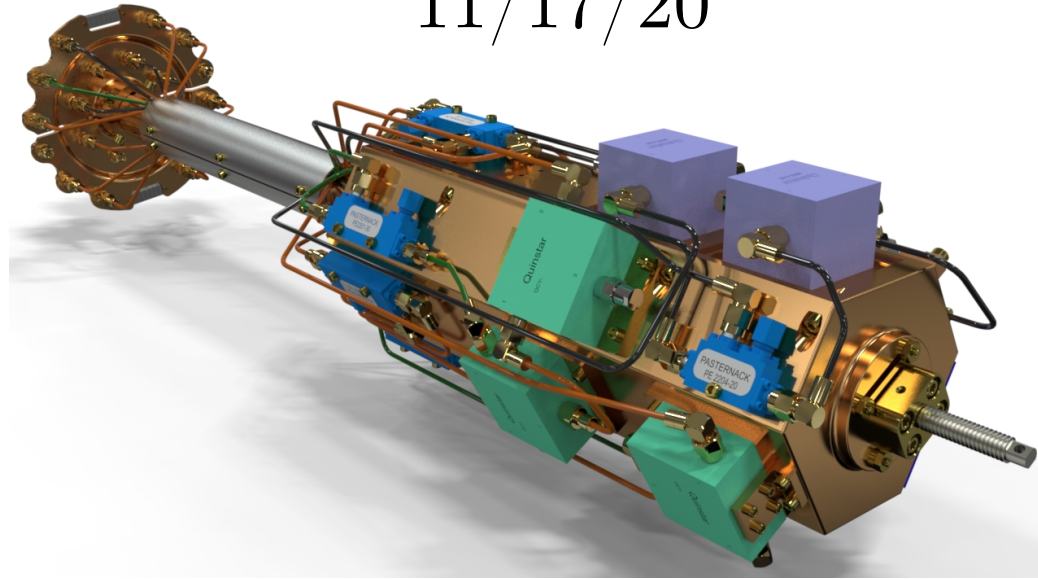


Squidadel and Upgrades for Run 1D and 2A/B

ADMX Collaboration Meeting

11/17/20



Jim Buckley

Washington University in St. Louis

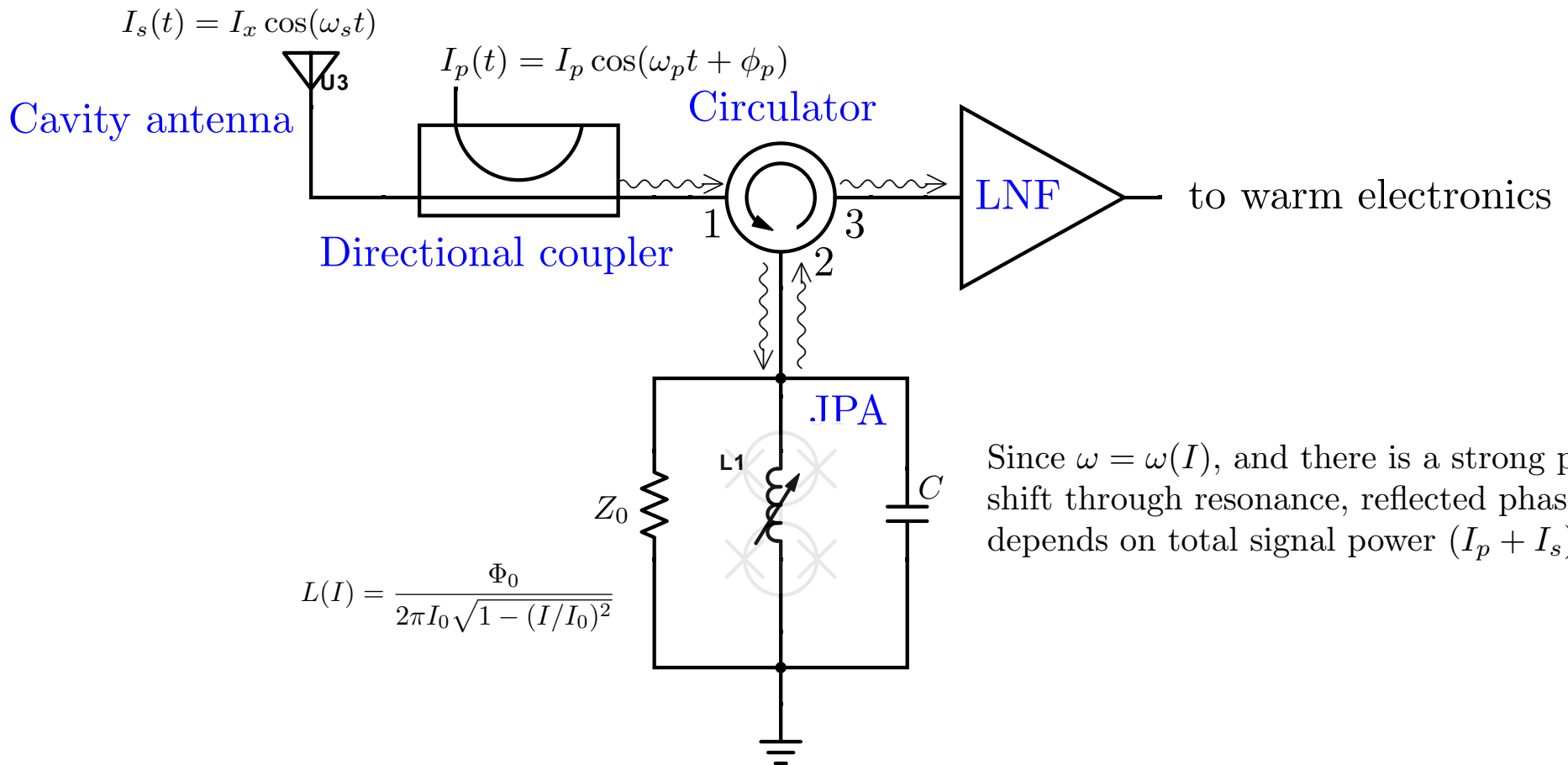
for Cold Electronics group:

- **Washington U:** [Dana Braun](#), Jim Buckley, Chandra Gaikwad, Erik Henriksen, [Jonah Hoffman](#), [Kater Murch](#), Izabella Pastrana
- **Fermilab:** Matt Hollister, Rakshya Khatiwada, [Don Mitchell](#)
- **LLNL:** Gp Carosi, Nathan Woollett
- **PNNL:** Christian Boutan, Mauro Grandi
- **U. of Washington:** Chelsea Bartram, Gray Rybka

Summary

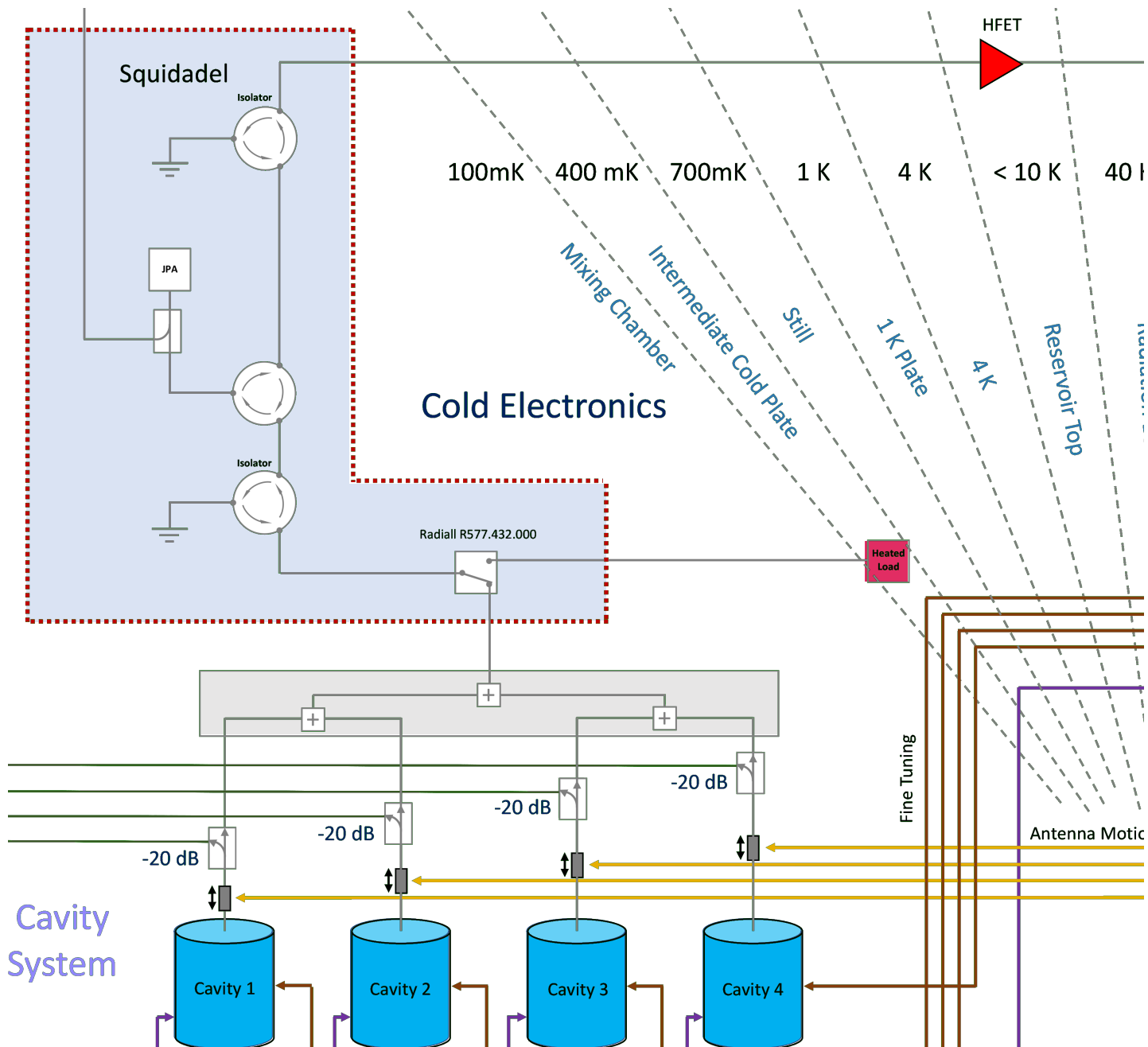
- Lots of effort over last 1.5 years setting up lab for ADMX cold electronics testing.
- Squidadel 2A mechanical design and fabrication of components complete.
- Two Run 2A 1.9 GHz JPAs packaged and tested (one at UCB, one at WU)
- Run 1D JPA tested at Berkeley (tests underway at WU) other parts can be packaged to make spare.
- WU Power combiner complete, tested.
- All parts for Run 2A Squidadel are complete.
- Still waiting for circulators in smaller package from Quinnstar, will go with existing units (modified Squidadel hardware)
- New, optimized circulator design for Run 1D covering 1.02-1.41 GHz ready to order.
- Squidadel assembly is beginning, and test fixture is being fabricated.
- Looking into future improvements: cryo filters for DC wiring, Radial switch box, upgrading test system with magnet.
- WU GS Jonah Hoffman will describe component test results.

Simplified Schematic

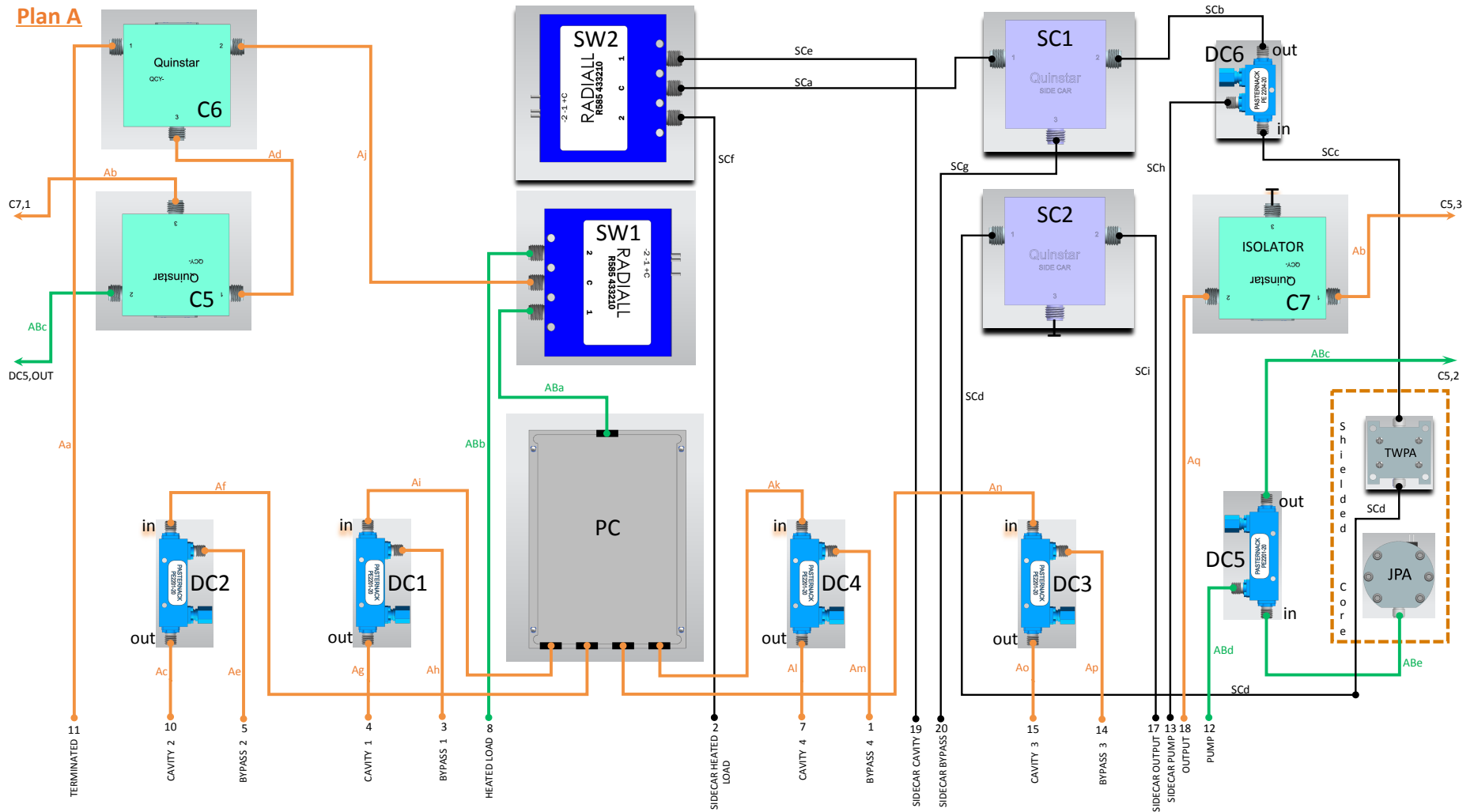


Since $\omega = \omega(I)$, and there is a strong phase shift through resonance, reflected phase depends on total signal power $(I_p + I_s)^2$

Run 2A Schematic

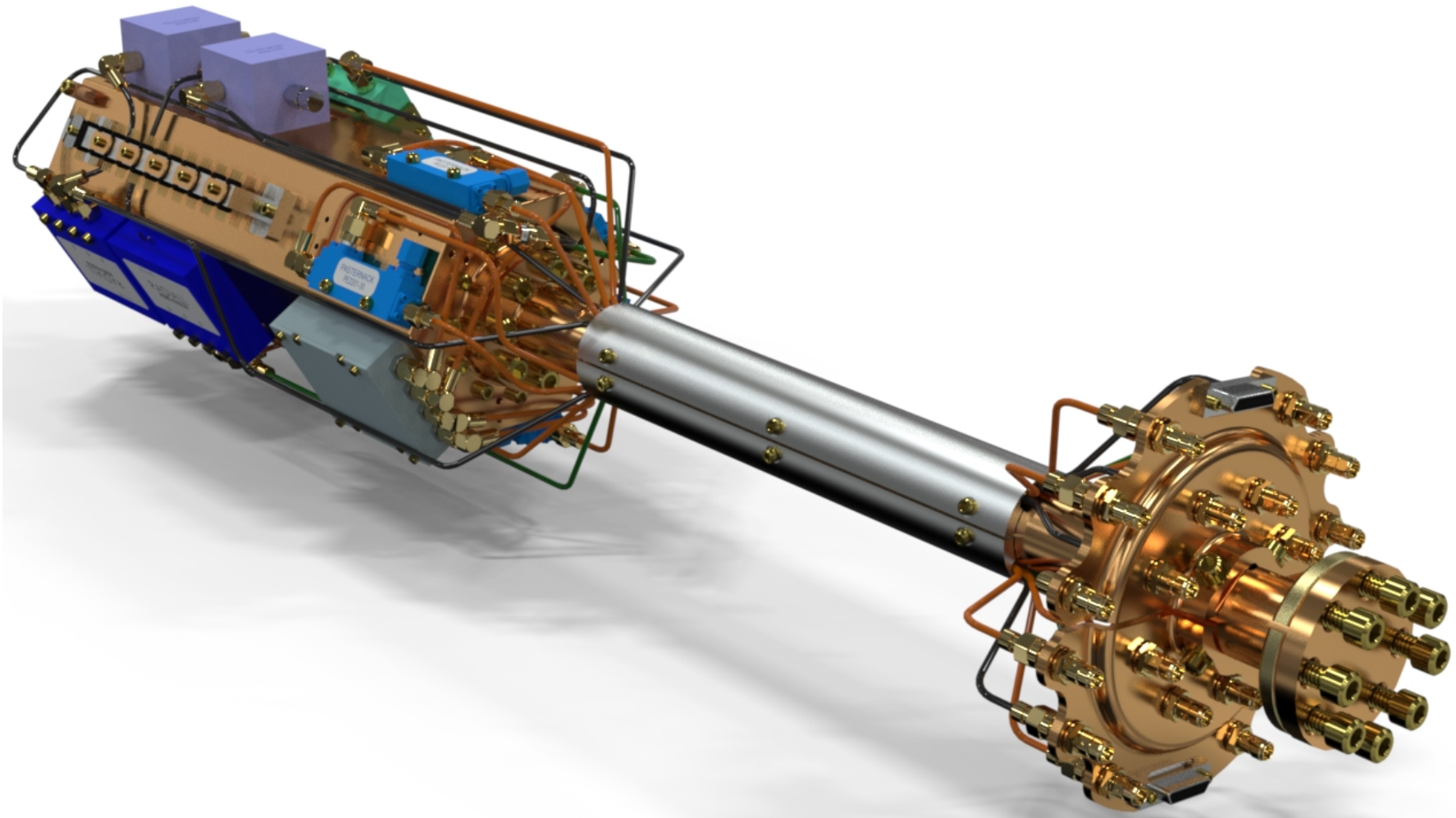


Run 2A Layout



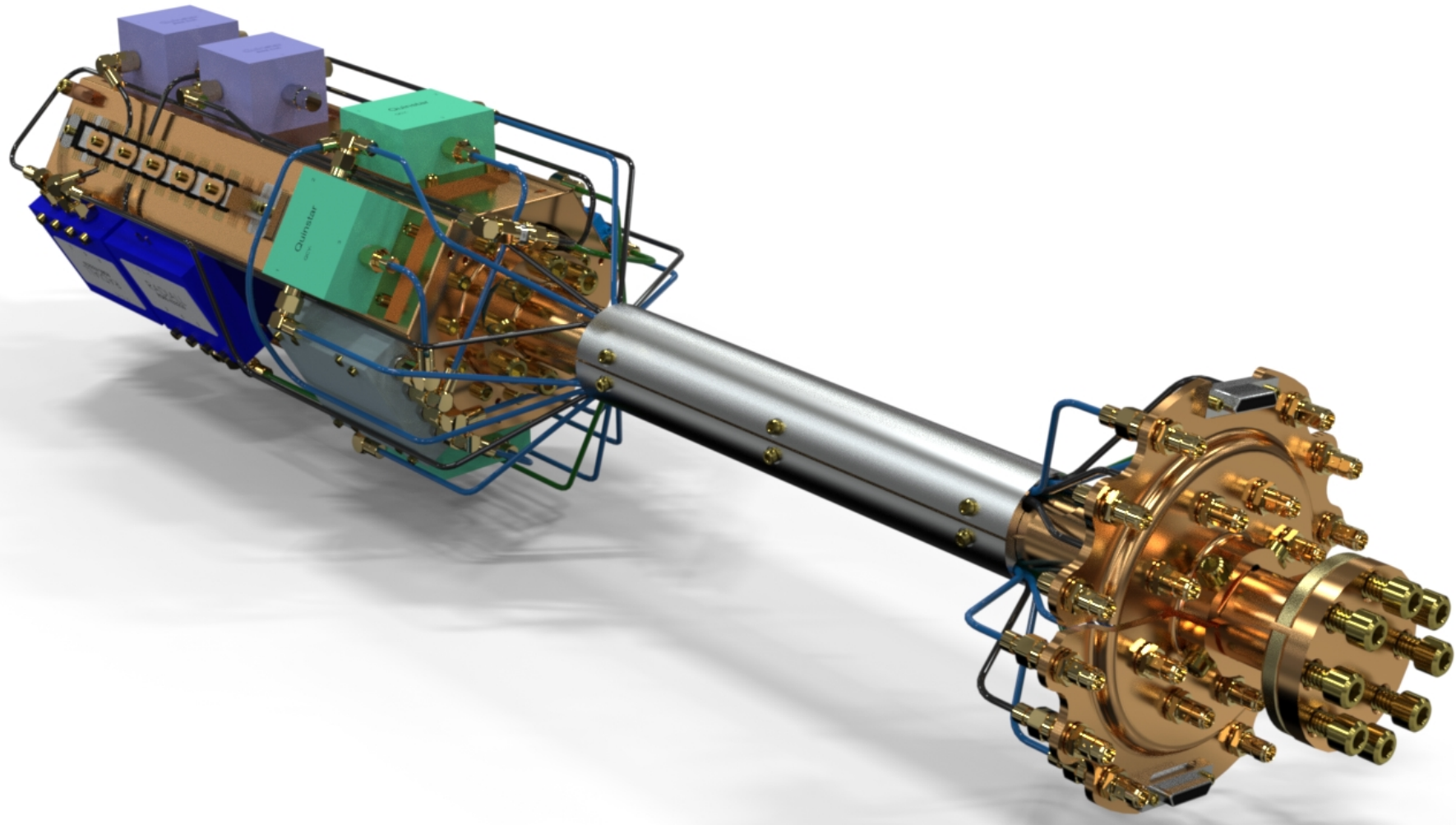
- Layout for baseline plan (Plan A)

Squidadel 2A



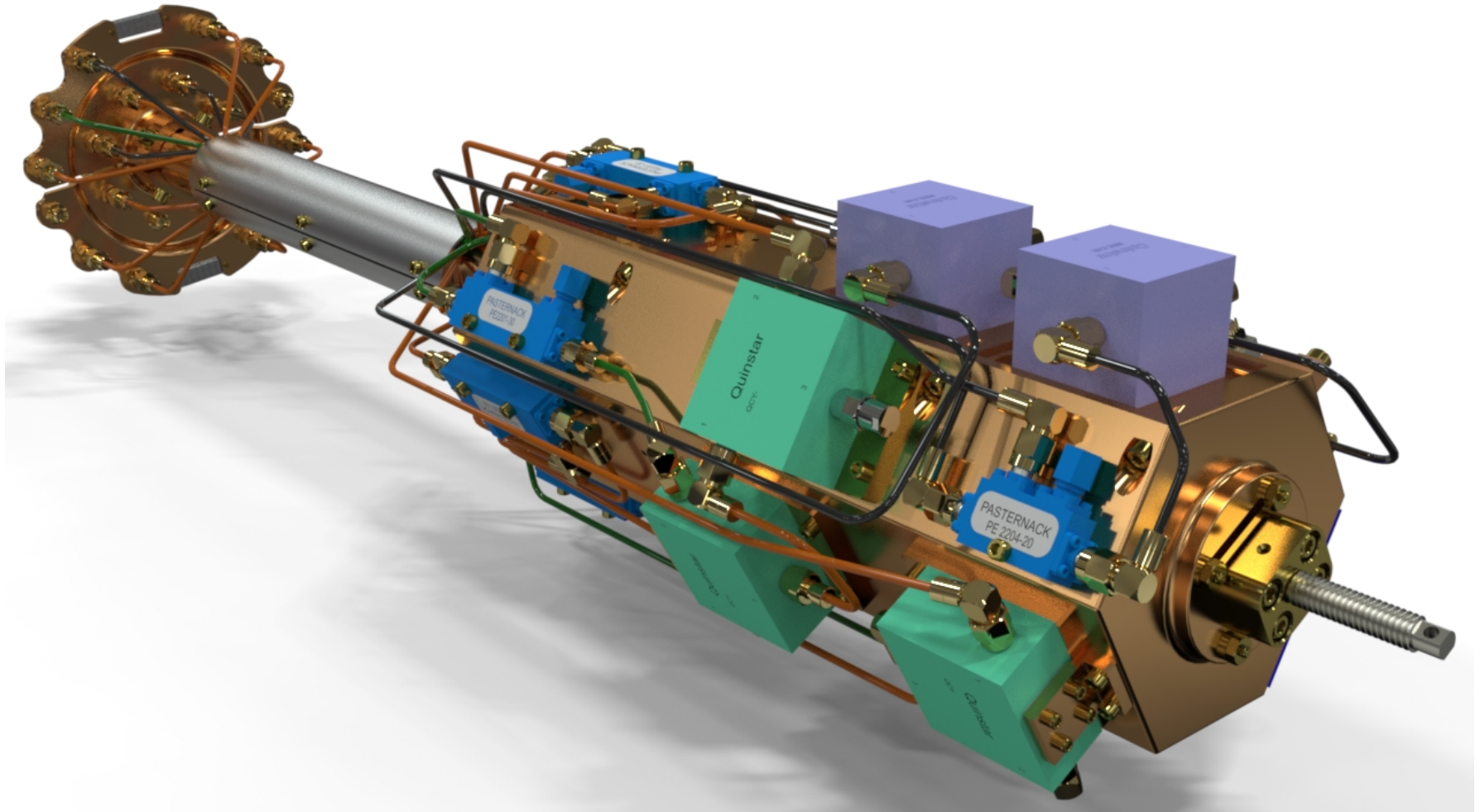
- Plan A - Directional couplers form bypass at front end, before power combiners

Squidadel 2A

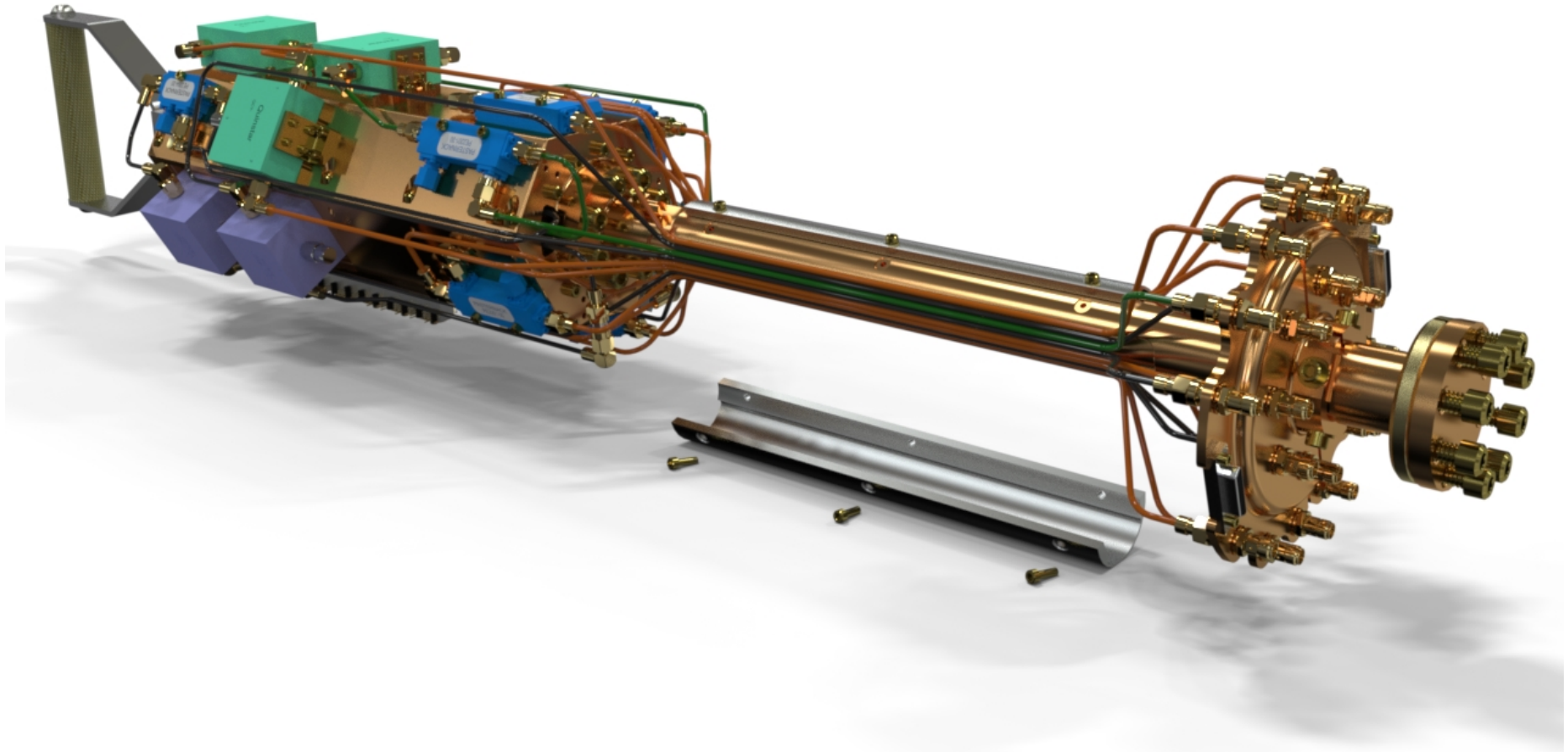


- Plan B - Circulators instead of directional couplers at front end, before power combiner

Squidadel 2A

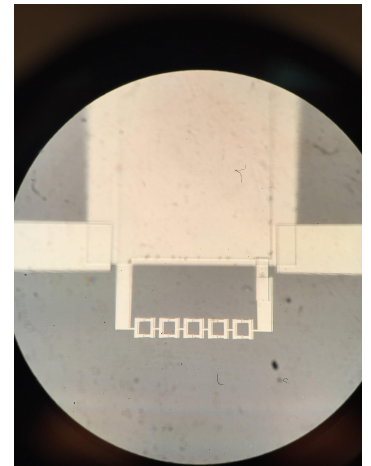
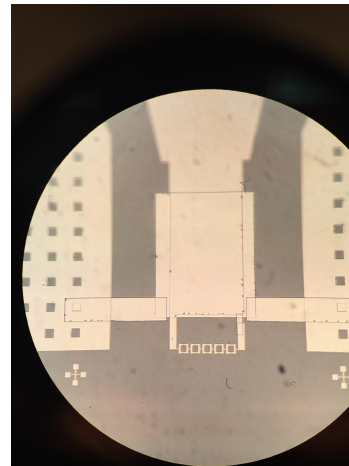
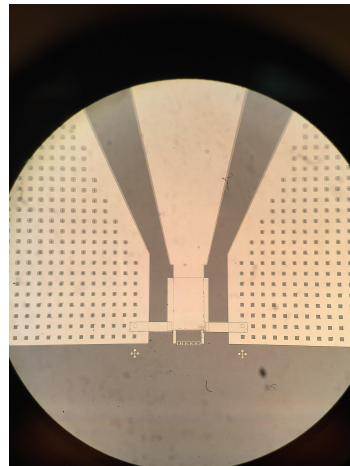
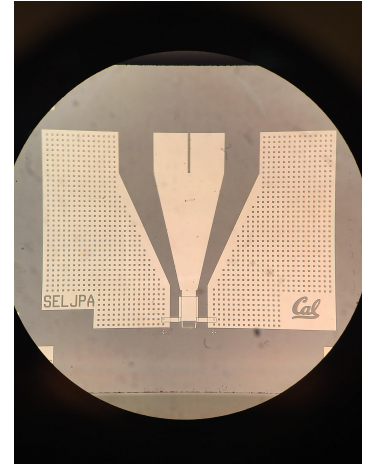
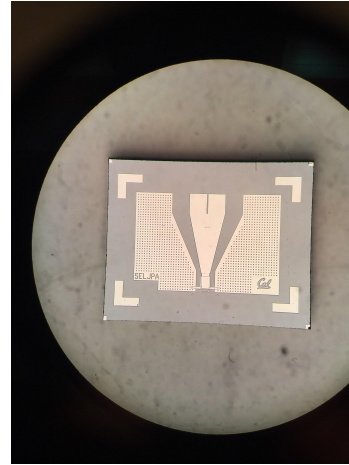
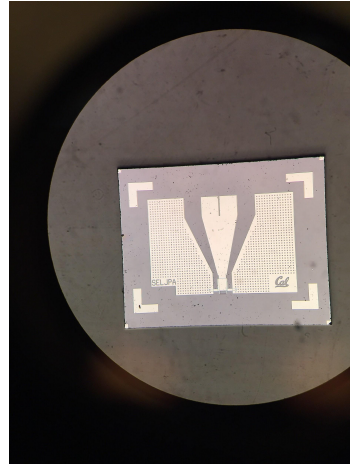
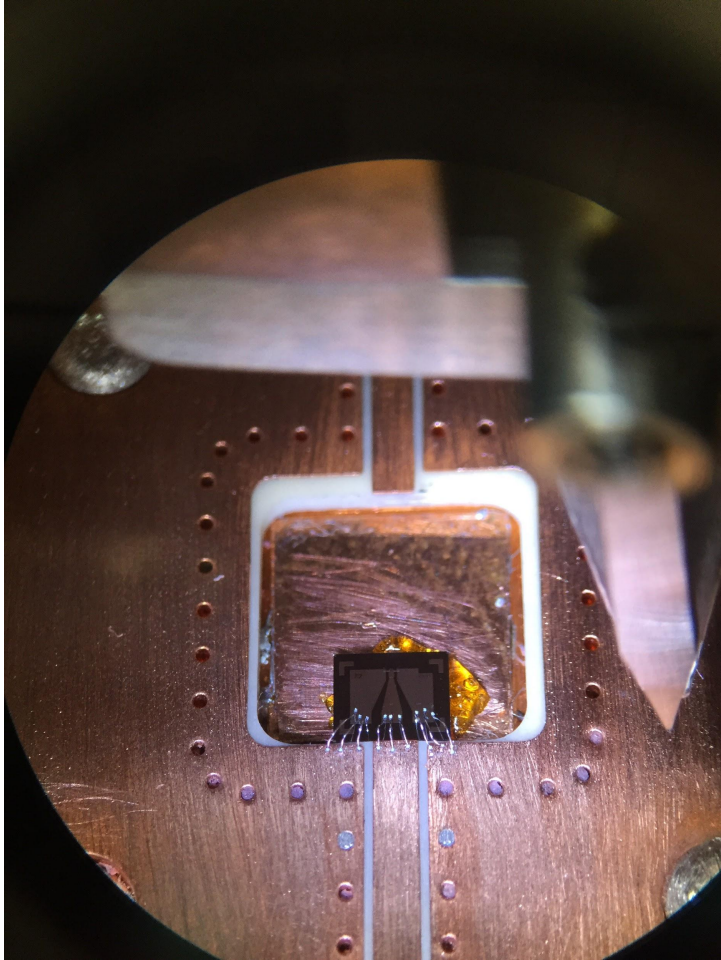


Squidadel 2A



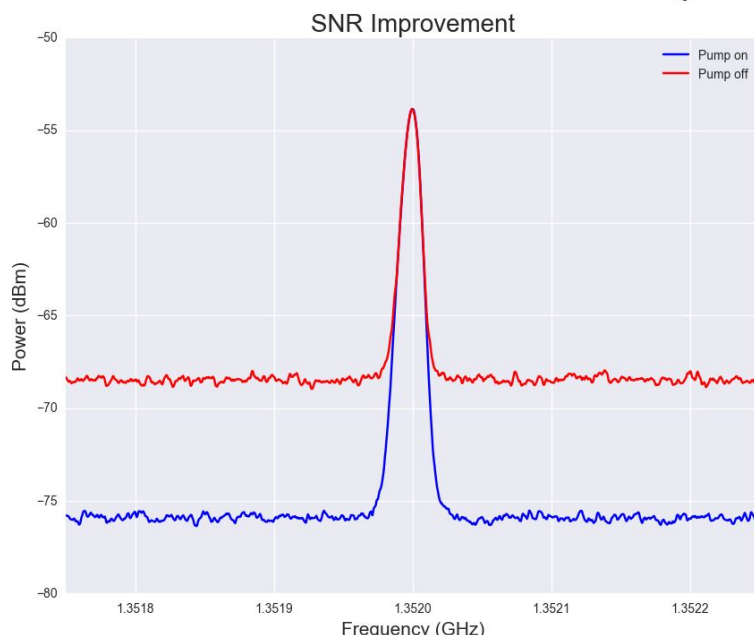
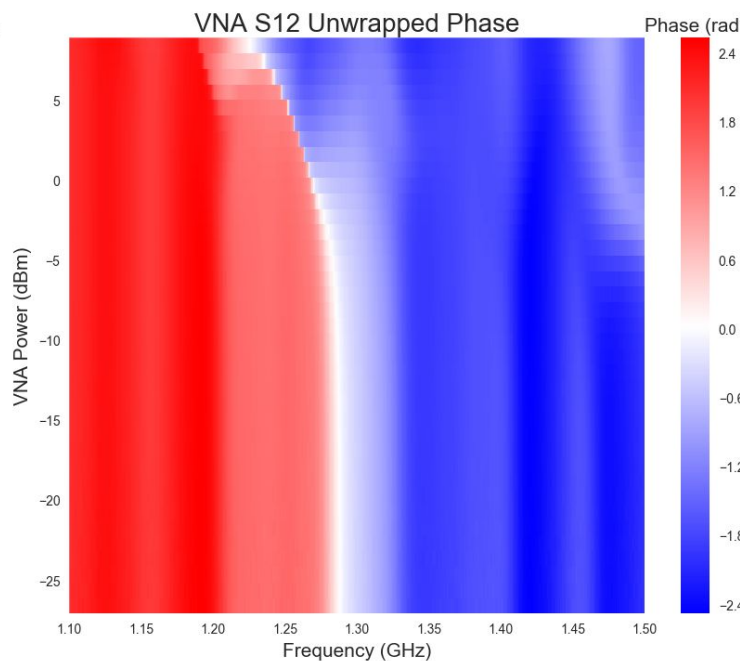
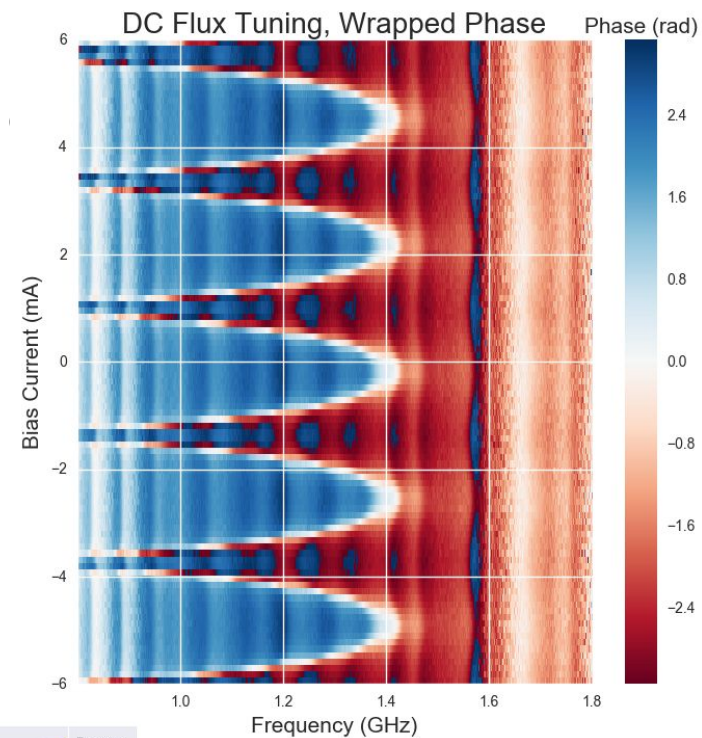
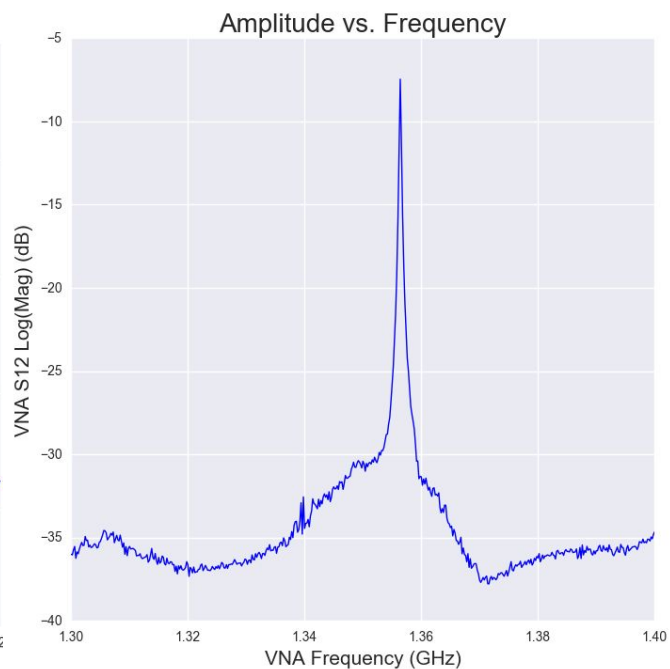
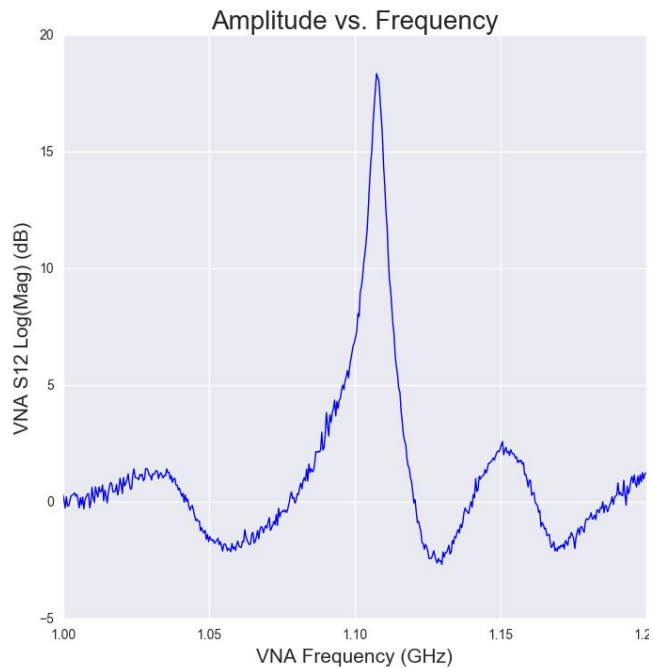
- Shown with handle and cable management. Not shown - insulating studs to eliminate touches.

UCB JPAs



- Photos of 1.4 GHz or 1.9 GHz JPA

Run 1D 1.4 GHz JPA

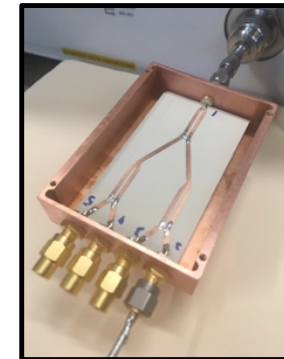
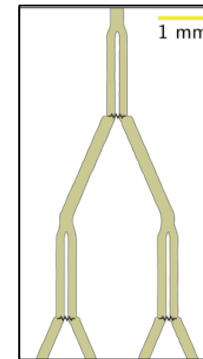


- Results from Akel, 1/29/2020

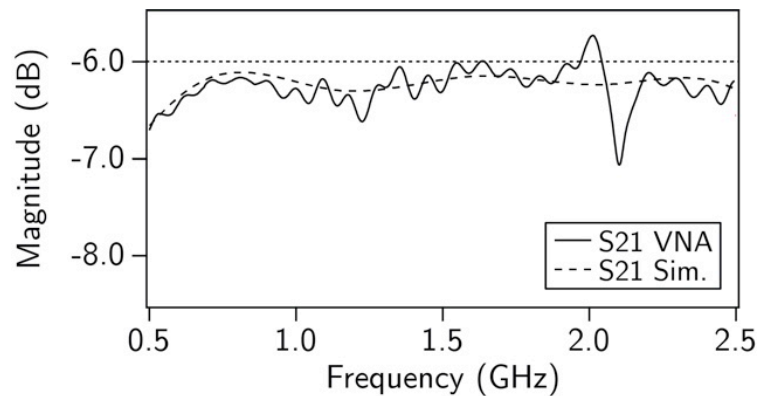
Power Combiner

Achievements - Wilkinson Power Combiners

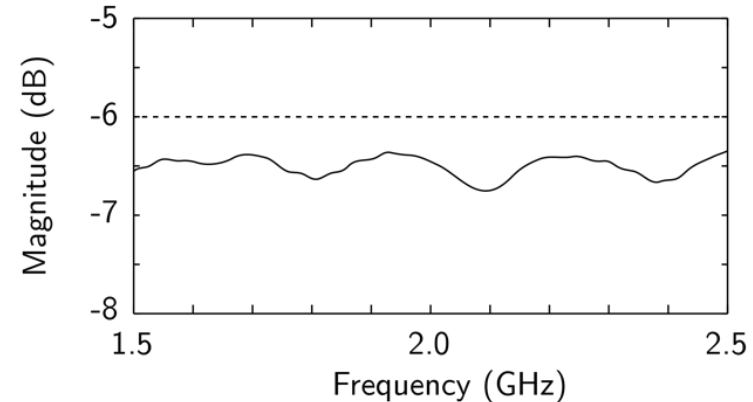
- Designed and fabricated Wilkinson power combiners at WU, using in-house RF PCB fab.
- Achieved target insertion loss.
 - All ports terminated: ideal transmission is -6 dB, additional insertion loss < 0.4 dB
 - Good agreement with simulations.



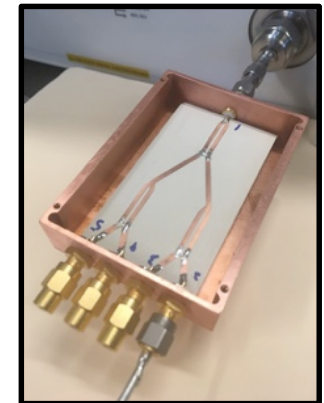
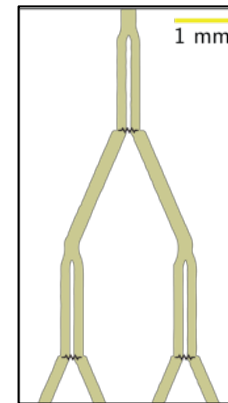
Room temperature



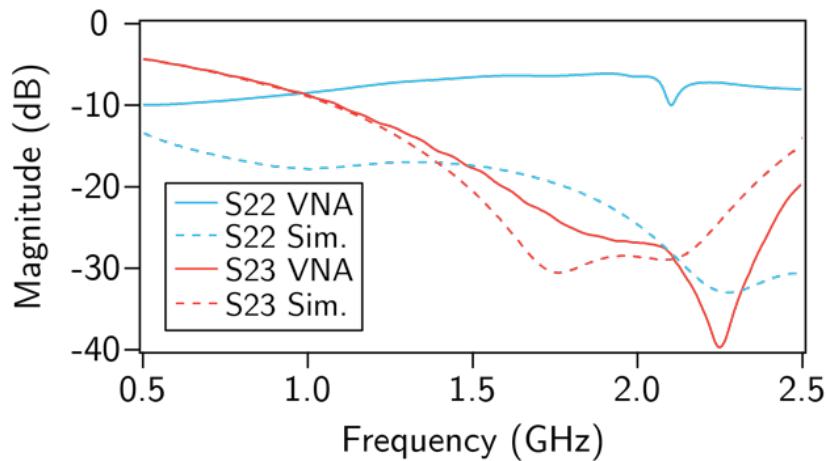
4 K / mK



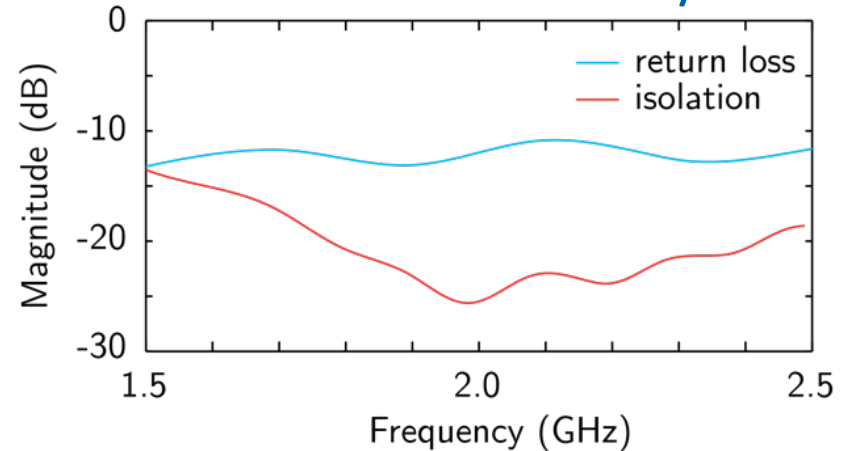
- Return loss (cyan)
 - Resonance from packaging (room temperature measurement)
 - Improving return loss by optimizing impedance matching
- Isolation (red)
 - Test isolation performance by combining cavity signals



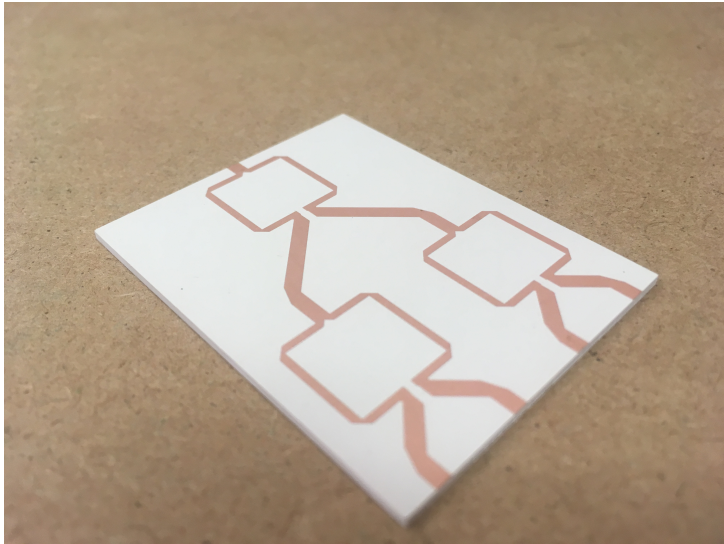
Room temperature



4 K / mK



Power Combiner



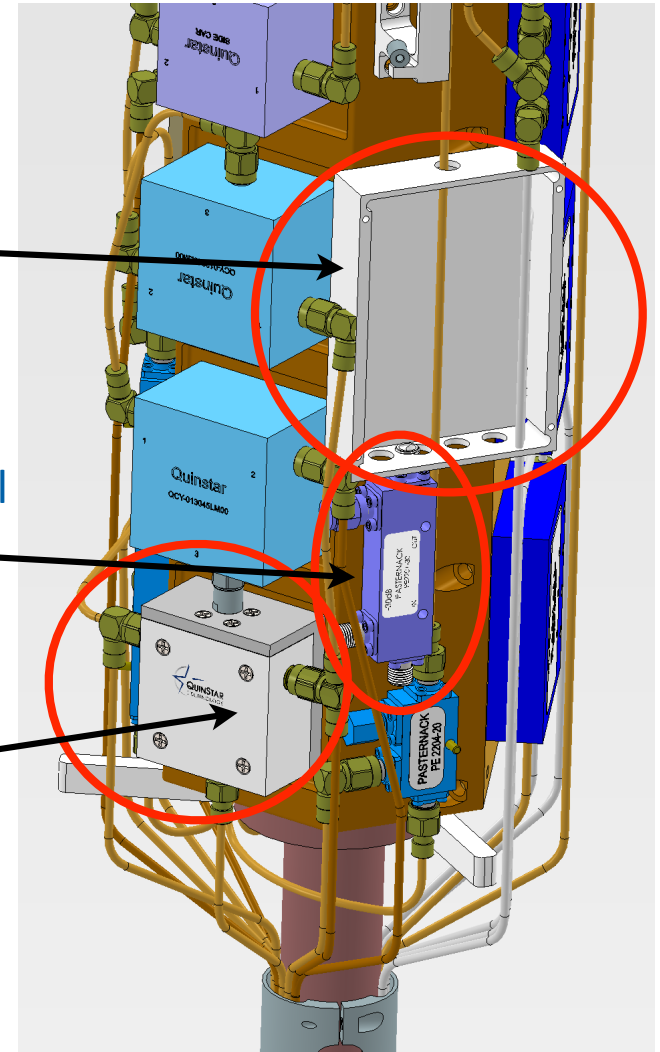
ponents

Power combiner
(needs to be smaller!)



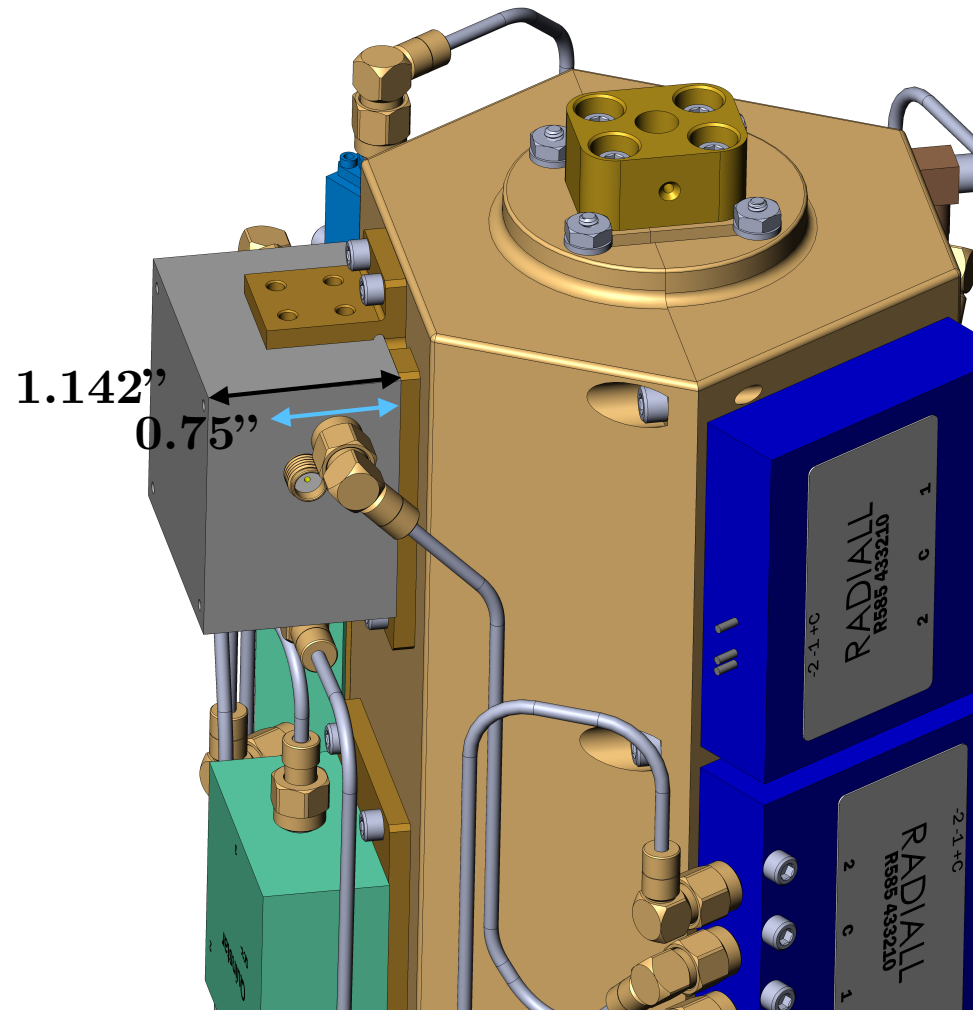
New directional
coupler

New circulator



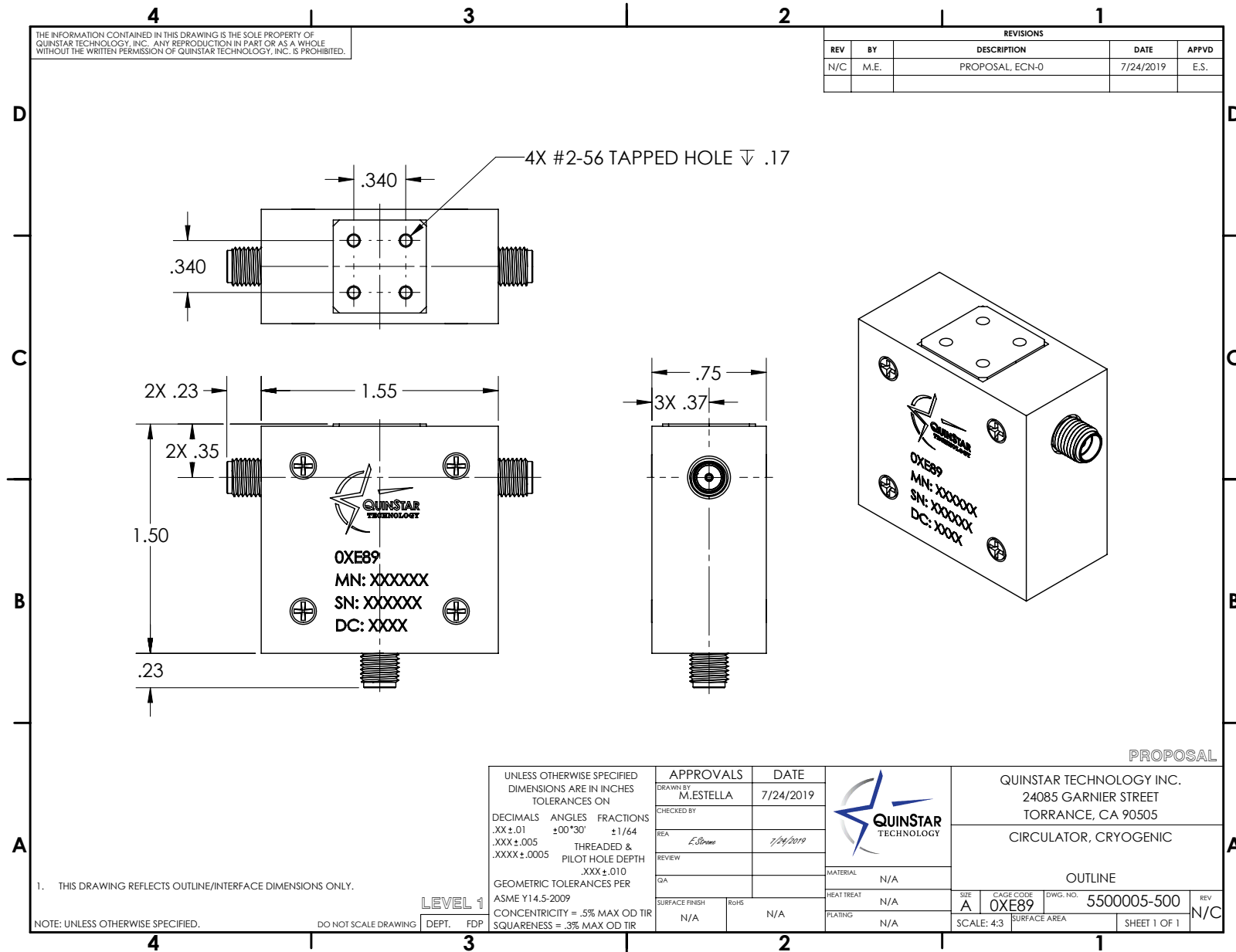
- Run 1C squidadel design was modified to accomodate new components, power combiner was made more compact to fit in Squidadel.

Impact on Squidadel



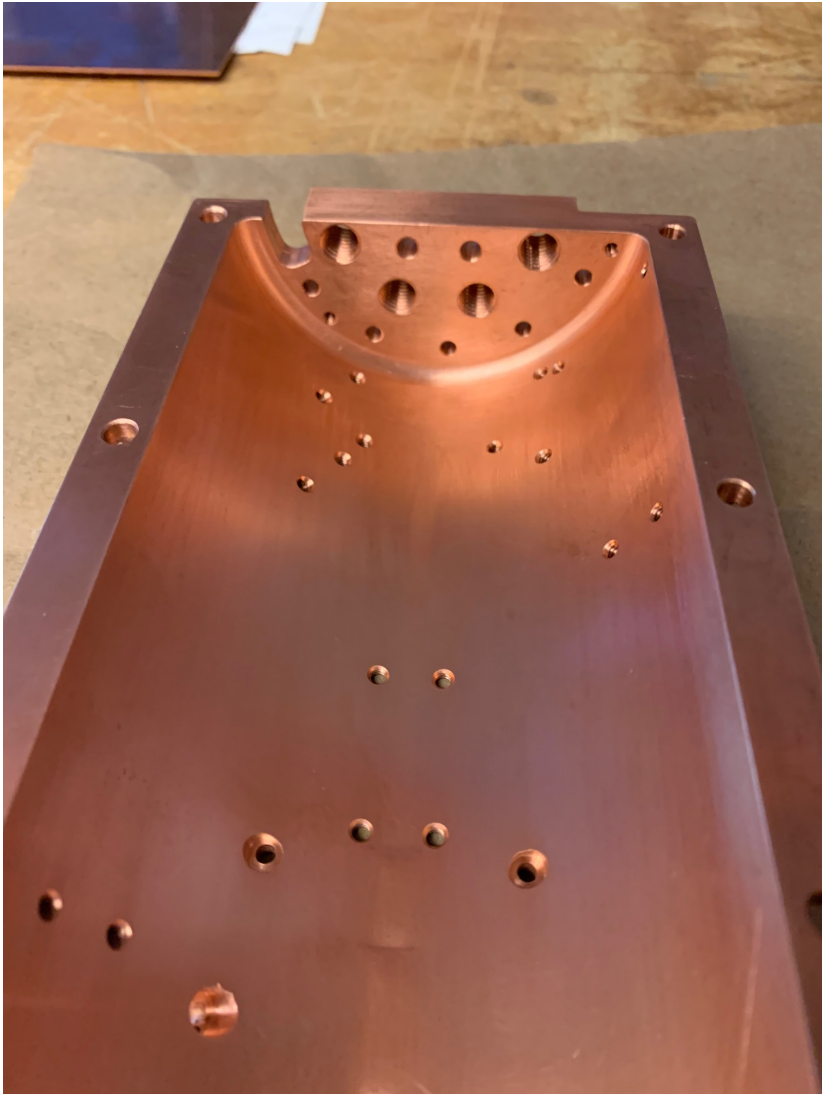
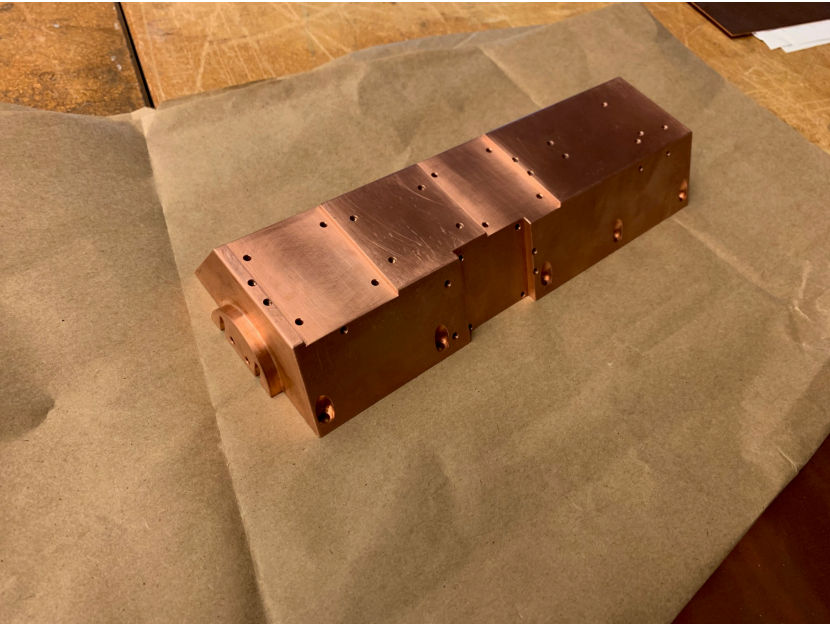
- 1.142" instead of 0.75 inches thick

Package As Ordered



- This is what we thought we would get!

Squidadel modification



- Parts machined in WU shop to allow mounting larger circulators.

Run-2A Squidadel Parts

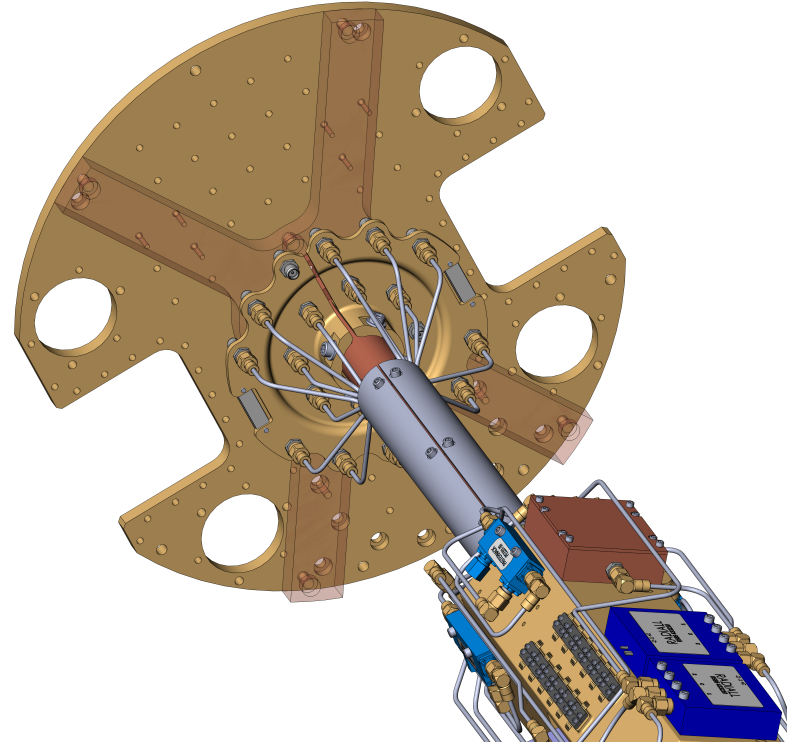


Run 2A Squidadel Parts



- Mechanical parts for Run-2A squidadel have been fabricated, and gold plated. Ready for assembly.

Squidadel 2A Test Setup



- Based on design used at LLNL for Run 1C squidadel testing (Left), WU designed and fabricating mounting bracket for squidadel testing in Wash U. BF-LD250 fridge.
- Both WU and LLNL LD250 had a custom, extended tail section to allow Squidadel testing.

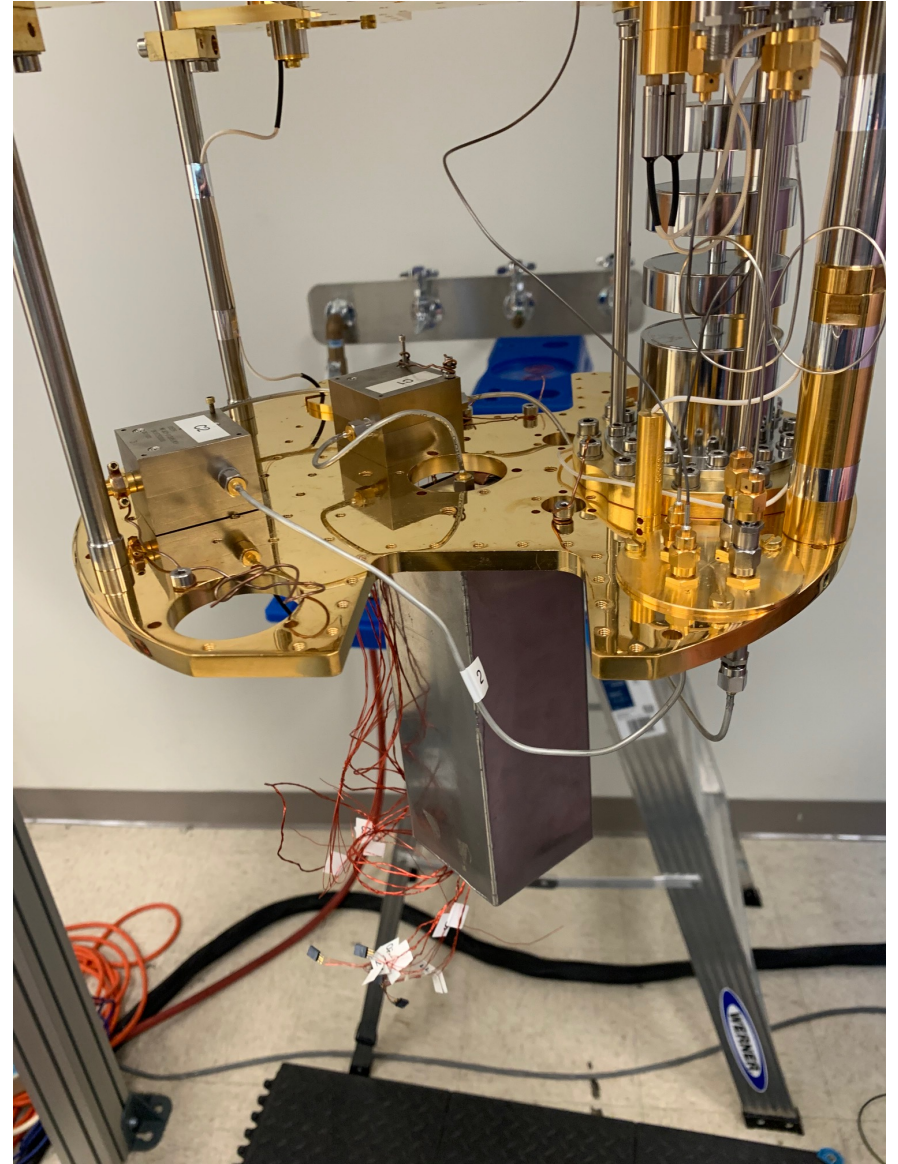
ADMX / X-ray Dil Fridge Lab



- WU BF-LD250 fridge (shared by Buckley and Krawczynski) includes LLNL style extended tail section for testing Squidadel.
- First light (or first He-3) March 1, 2019

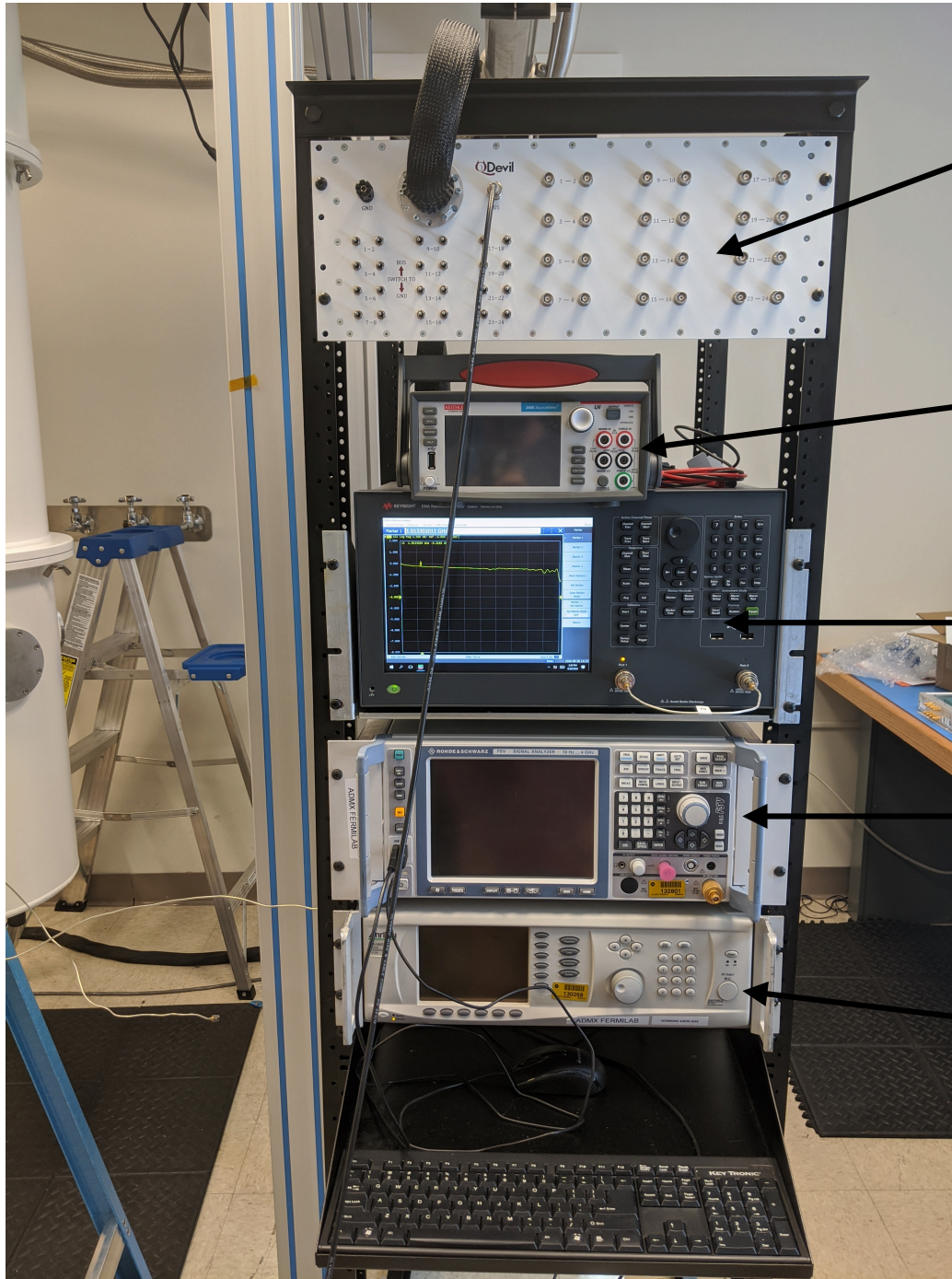
- Kater has 3 BF LD250s, Erik has 1 BF LD400 with 14T magnet.

JPA Component testing...



- WU GS Jonah Hoffman putting together Run 1D JPA test setup (with proper social distancing)

Lab Setup



Q-devil QBox 24 channel fully shielded Fischer to BNC breakout box

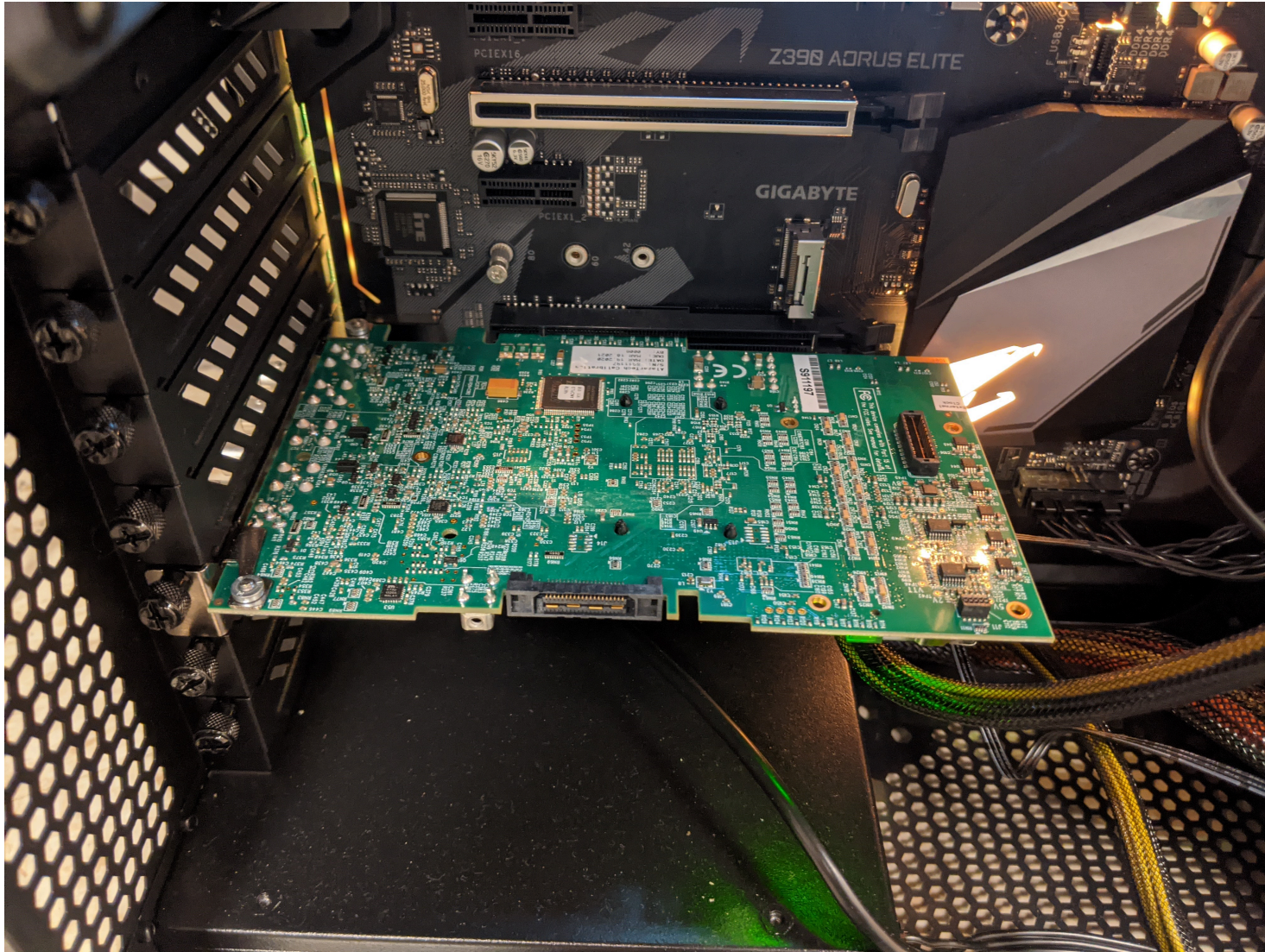
Keithley 2450 source meter with 1k series resistor and filter

Keysight E5063A-285 8.5 GHz VNA

Rhode and Schwartz FSV 10MHz-4GHz spectrum analyzer (FNAL govt. excess)

Anritsu M63692B RF signal generator (FNAL govt. excess)

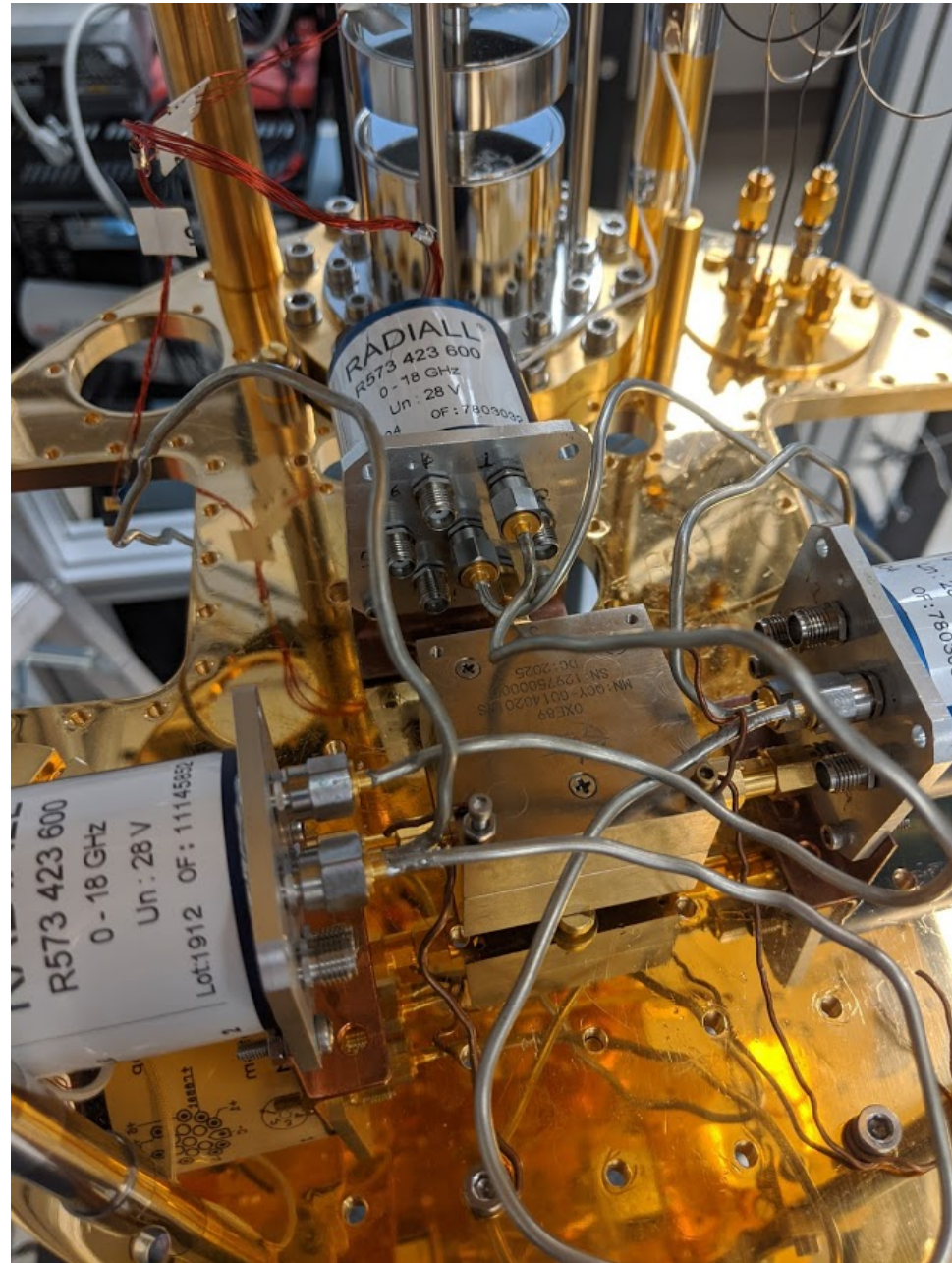
DACQ System



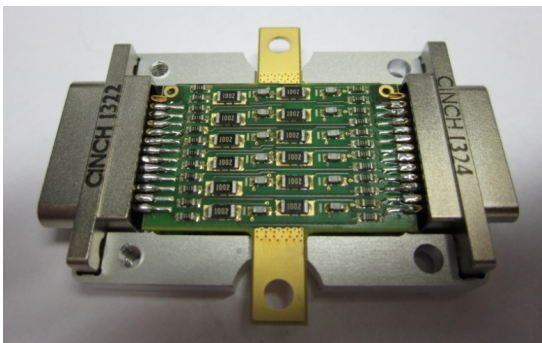
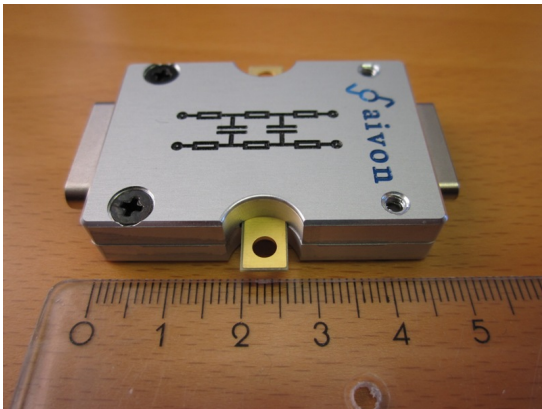
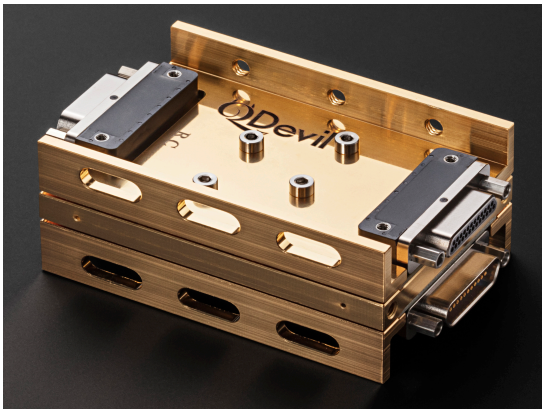
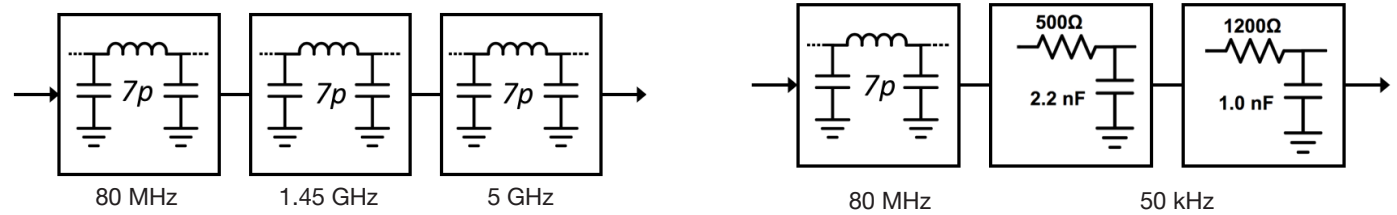
- Added Alazar board (need receiver components) for extended frequency development

WU Cryo Test System

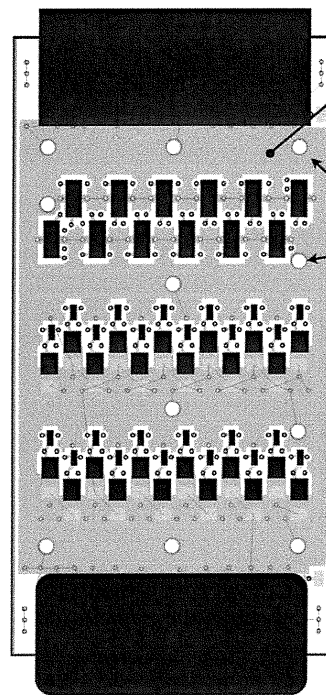
- 3 modified 6-way Radial switches at mixing chamber,] for efficient JPA/circulator and other component testing down to $\sim 10\text{mK}$.
- Working on new switch controller. WU Engineer Izabella Pastrana will work with Jonah to design and layout PCB



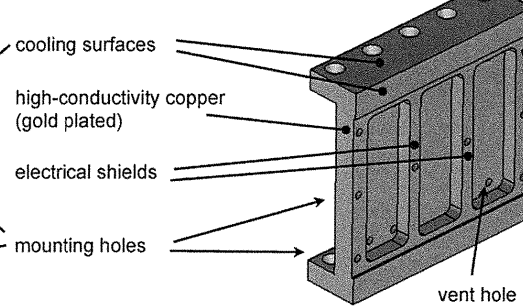
Filter Upgrade








Topview of RC-PC board*:



mounting bracket:



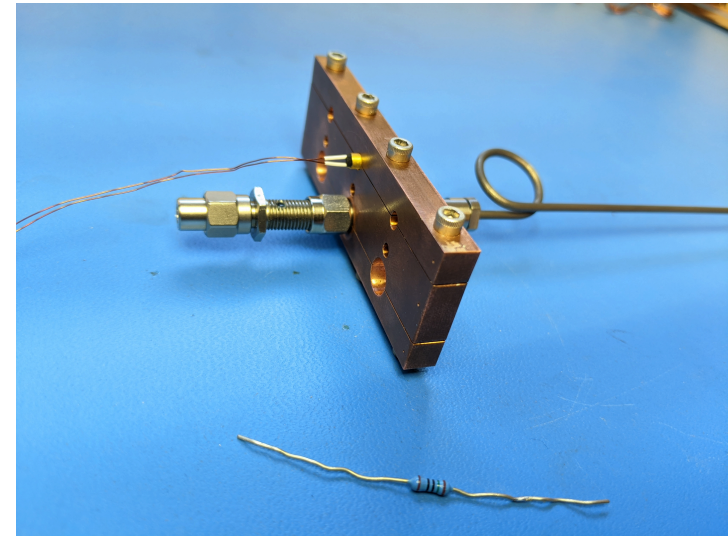
-  80 MHz low pass pi-filter, Mini-Circuits, LFCN-80
-  Murata capacitor 5...100nF, Digi-Key 490-5322-1-ND
-  Susumu resistor 2k, Digi-Key RR05P2.0KDCT-ND
-  micro-D connector 25 pin, non-magnetic Cristek Interconnects P/N C43-00069-04
-  micro-D connector 25 pin, non-magnetic Cristek Interconnects P/N C43-00070-04

* bottom view similar, with same components.

- Pi or Pi/RC filters for high power, low power DC/low frequency lines
- Manufactured by QDevil and Aivon, but based on Harvard patent of design by Kuemmeth and Marcus (Copenhagen).

Future Improvements

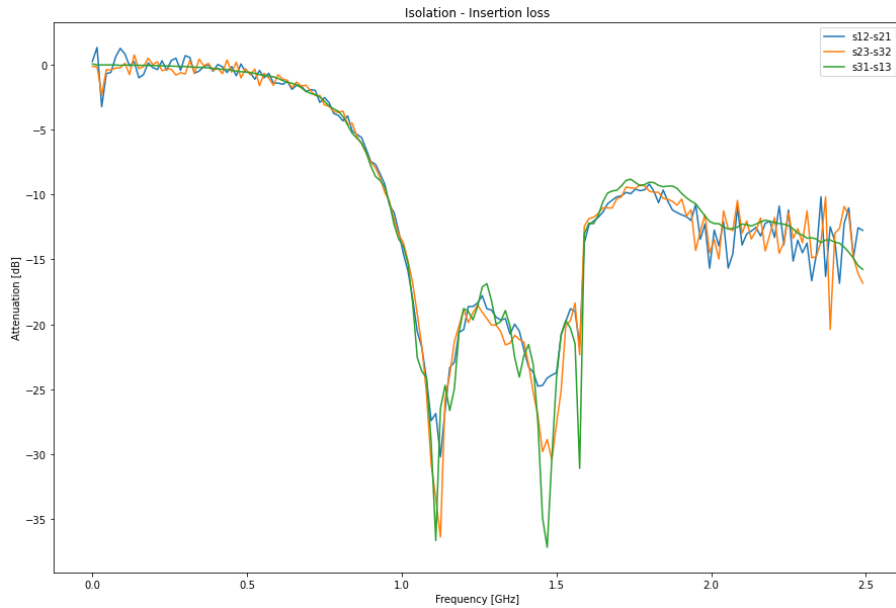
- New hot load/temperature sensor under construction
- With Erik Henriksen, working on development of filters for low-frequency lines.
- With Erik, will wind a small SC magnet for testing components (fridge is magnet ready with feedthroughs, but need to improve 4K cryocooler).
Obtained Quote from Bluefors for



Row	Item ID	Quantity	Unit Price	Price USD
10	Cryogen-Free Magnet, Integrated with BF-System A00387	1 pcs	91 450,00	91 450,00
	Magnet Spec: 1D 12T 76mm Compensated PSW Ready	1 pcs		
	<ul style="list-style-type: none"> • Field: 12 Tesla at 4.2K • Cold bore diameter: 76mm • Homogeneity: $\pm 0.1\%$ over 1cm DSV • Approximate weight: 57 kg • Field compensation: <1000 gauss at Z = 14.0" (356 mm) 			

- Working on design of switch controller PCBs (Jonah and Izabella)

Cryo. Circulator Tests



- Test results on back-up Run 1D circulator, showing all S-parameter measurements at $\sim 10\text{mK}$, determined in a single cool down.
- Test setup is working, low insertion loss and good isolation down from 1.0 - 1.5 GHz

