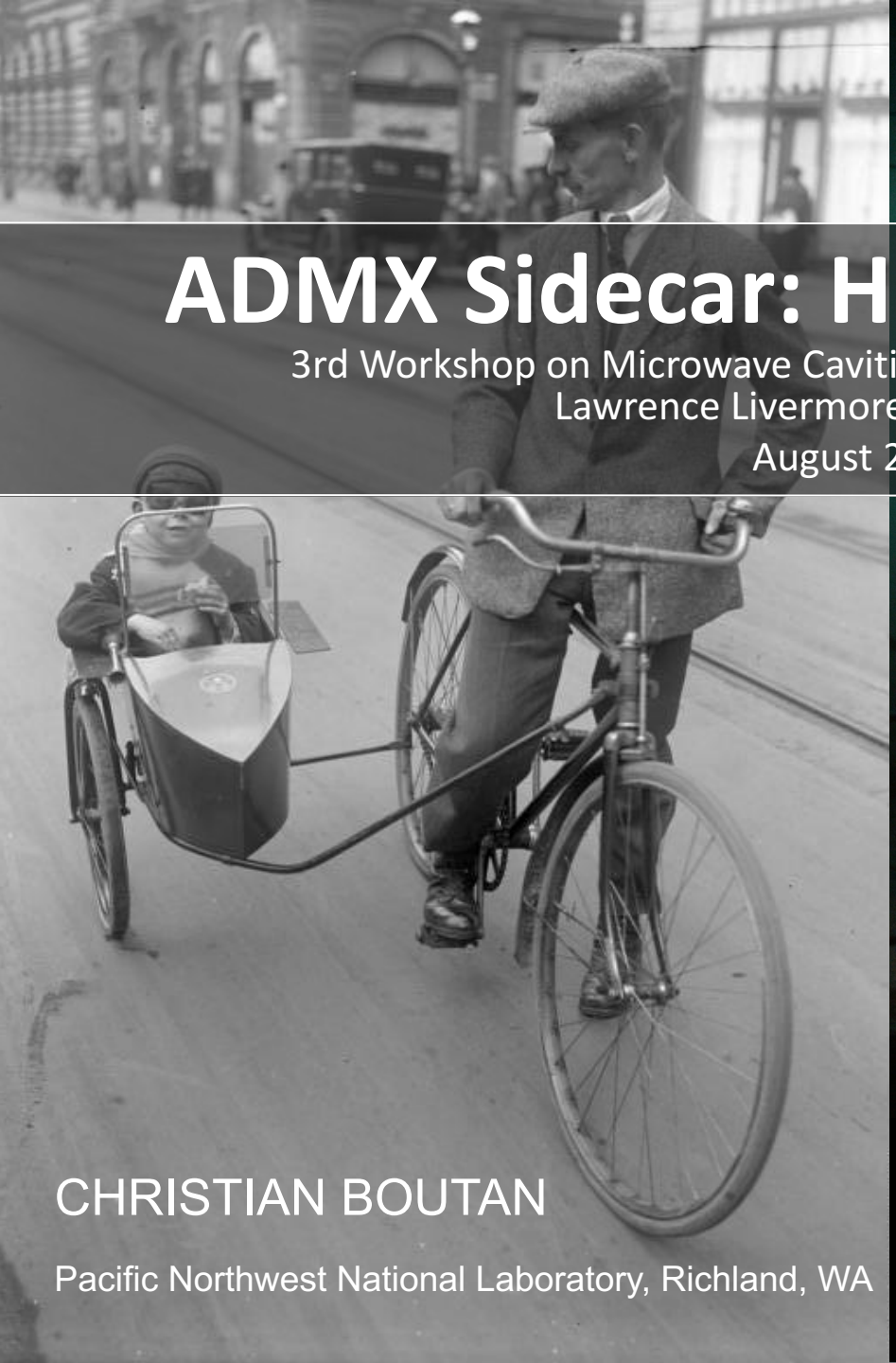
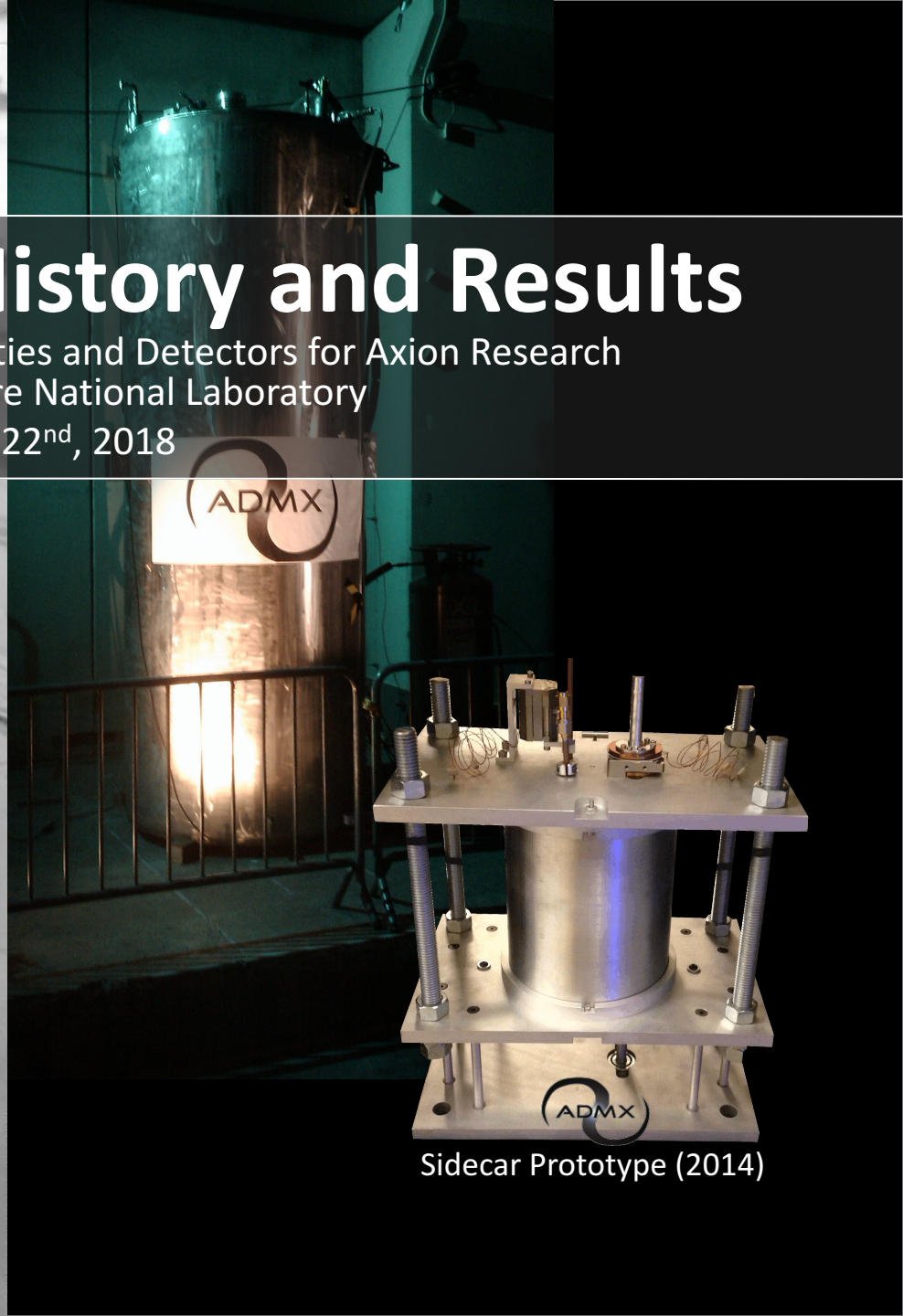
ADMX Sidecar: History and Results

3rd Workshop on Microwave Cavities and Detectors for Axion Research
Lawrence Livermore National Laboratory
August 22nd, 2018





Sidecar Prototype (2014)

CHRISTIAN BOUTAN

Pacific Northwest National Laboratory, Richland, WA

Real Estate for a high-mass Axion search

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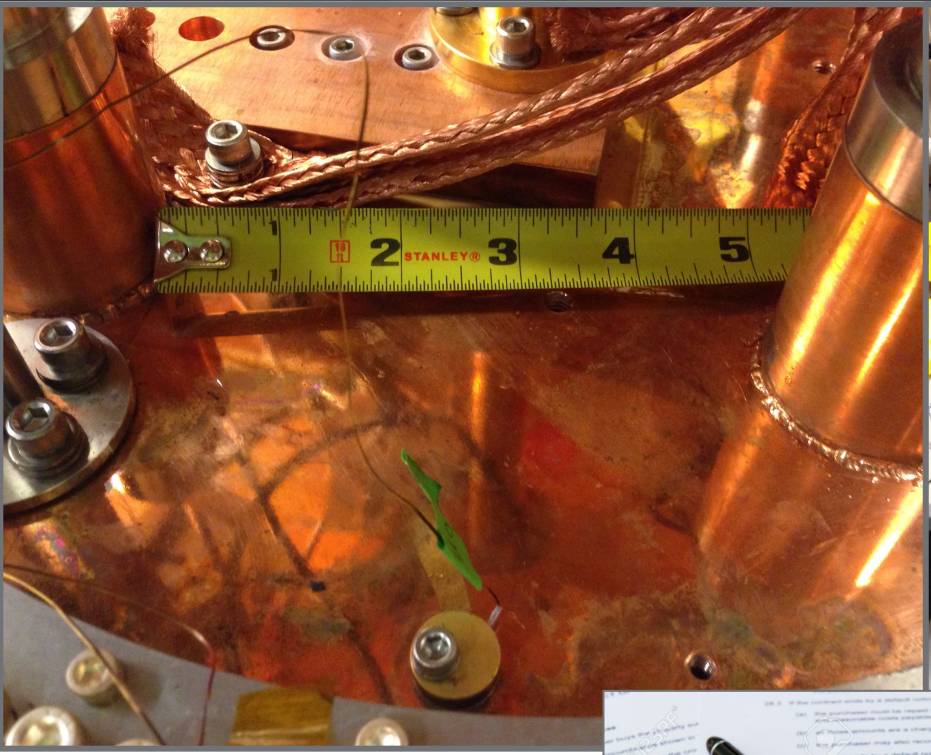
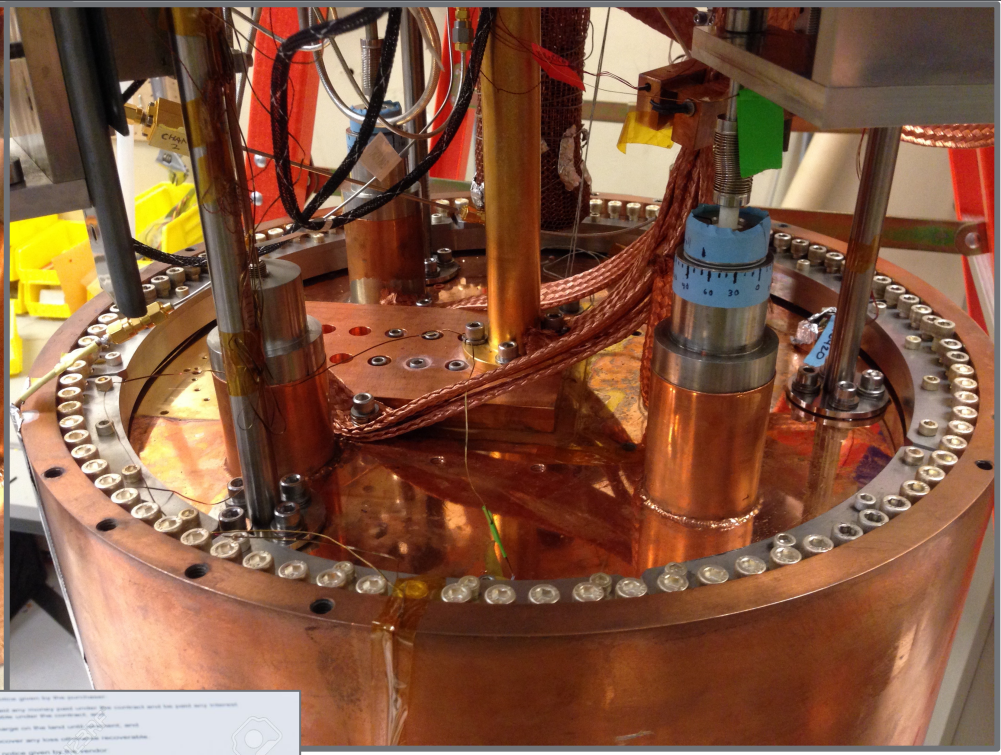
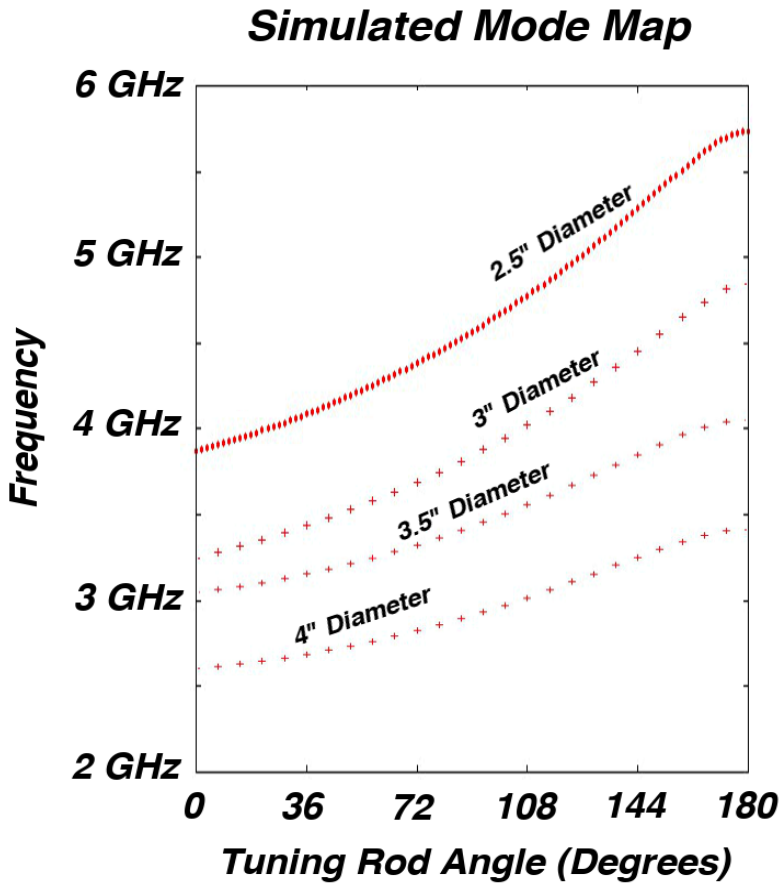


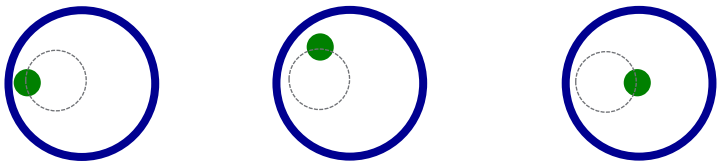


$3x10^{-6}$ Acres!

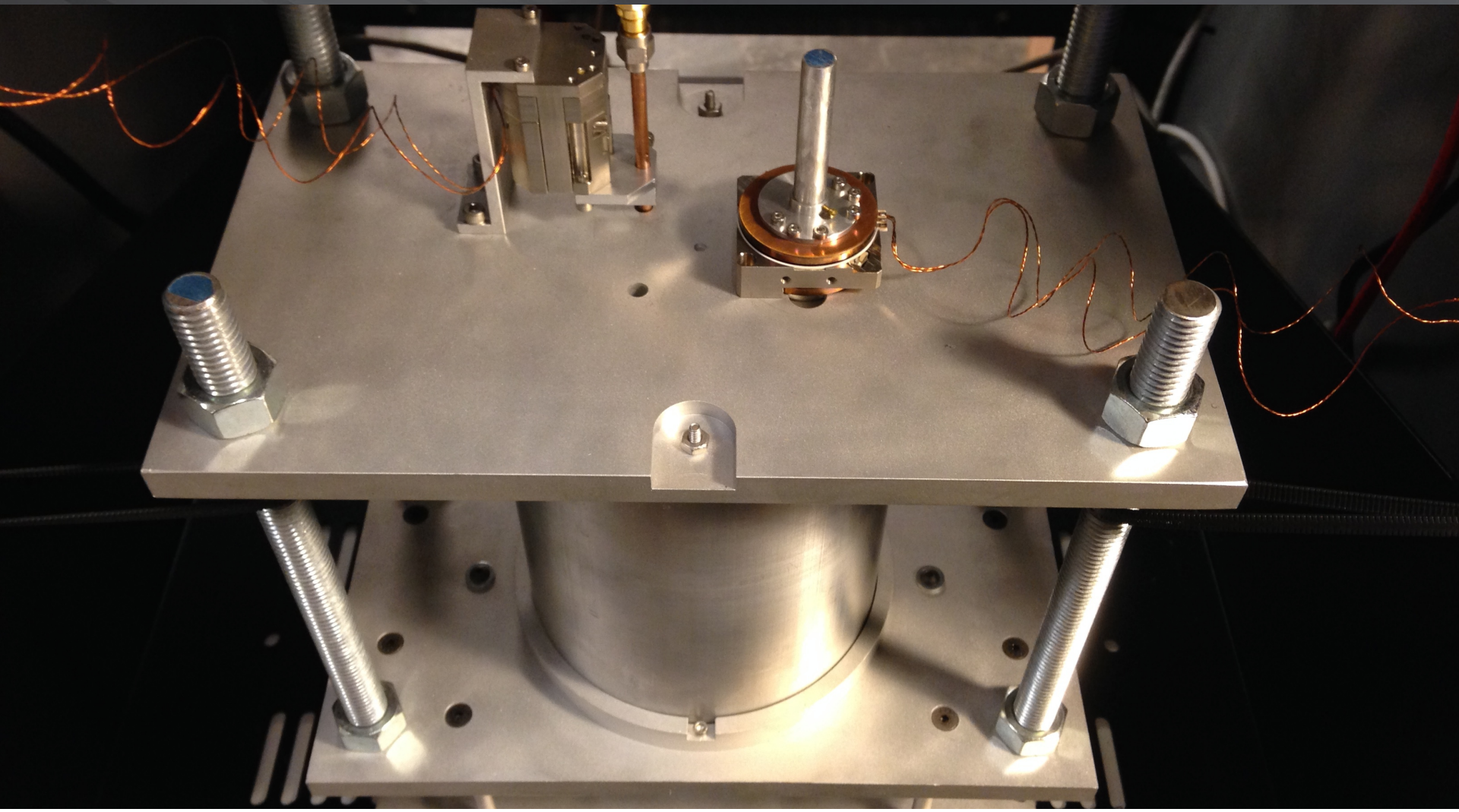
Goals
- Explore higher frequencies
- Investigate new techniques
- Make it scalable

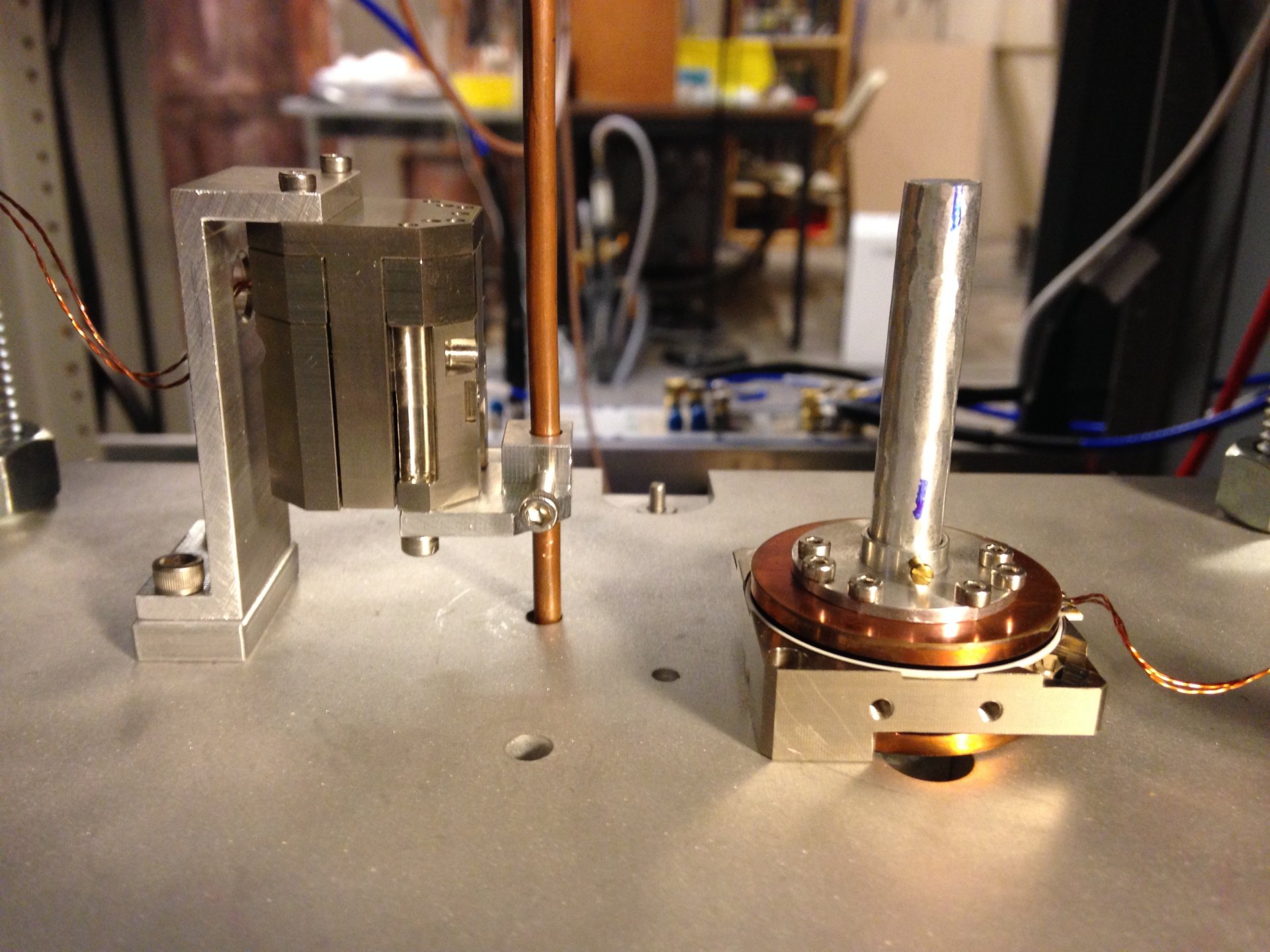
Cavity Design



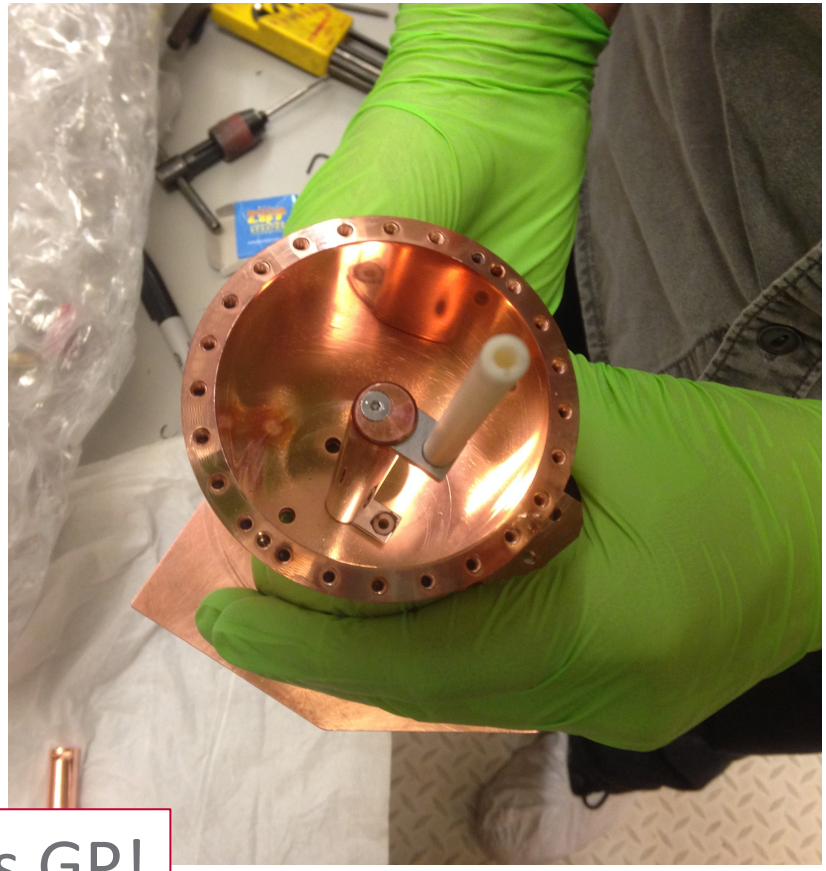


Motors on Test Cavity





Actual Cavity made at LLNL

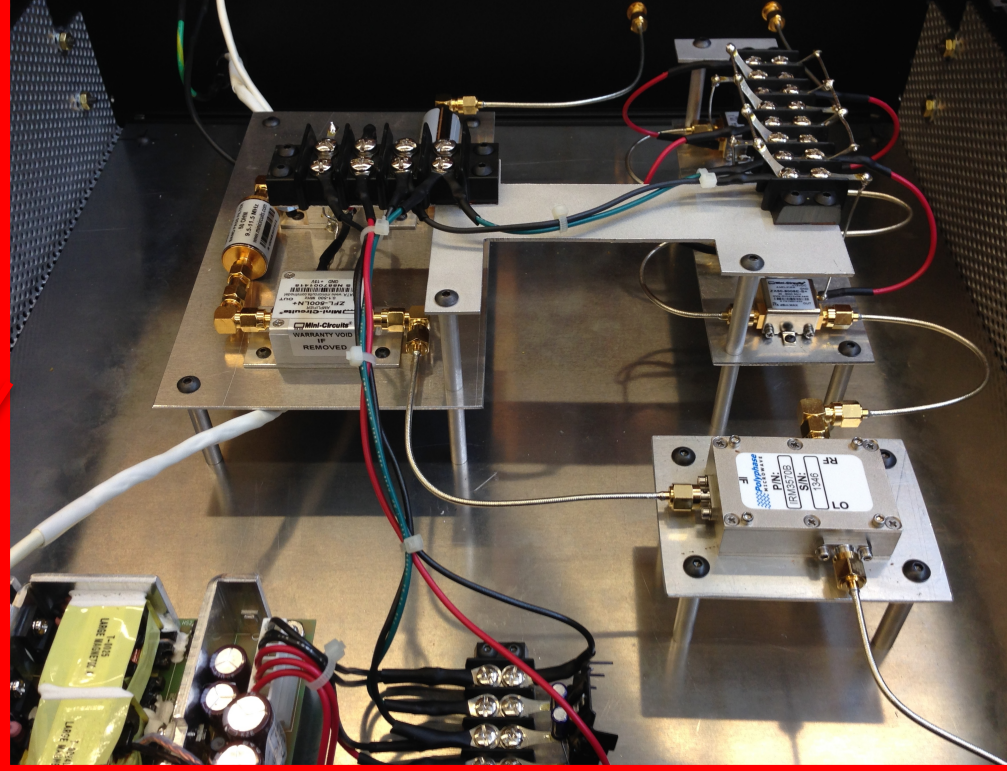


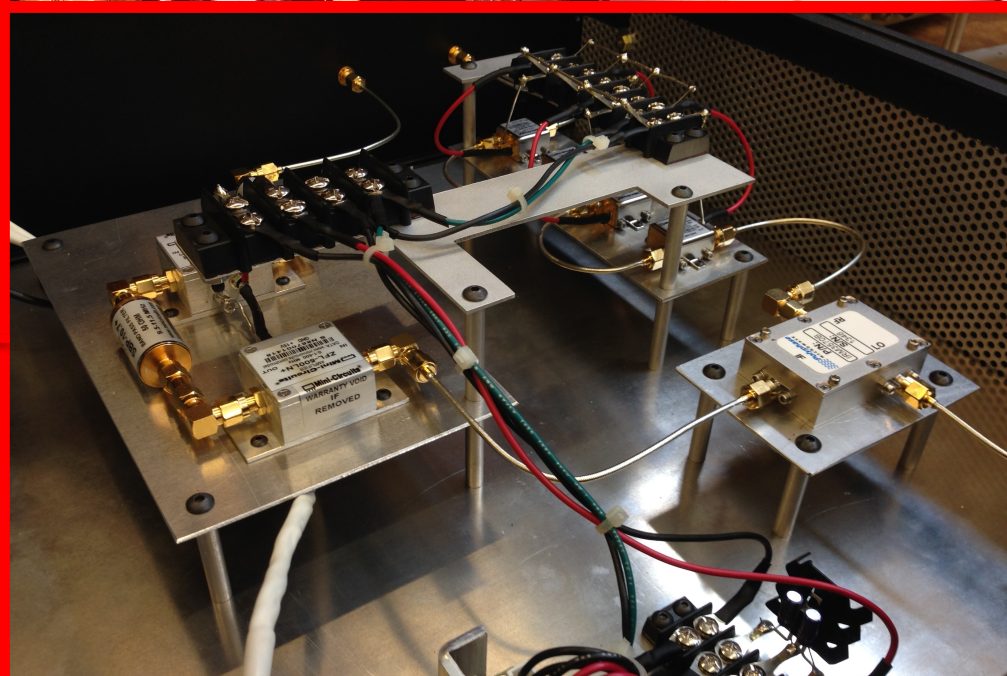
Thanks GP!

Sidecar Receiver

Receiver

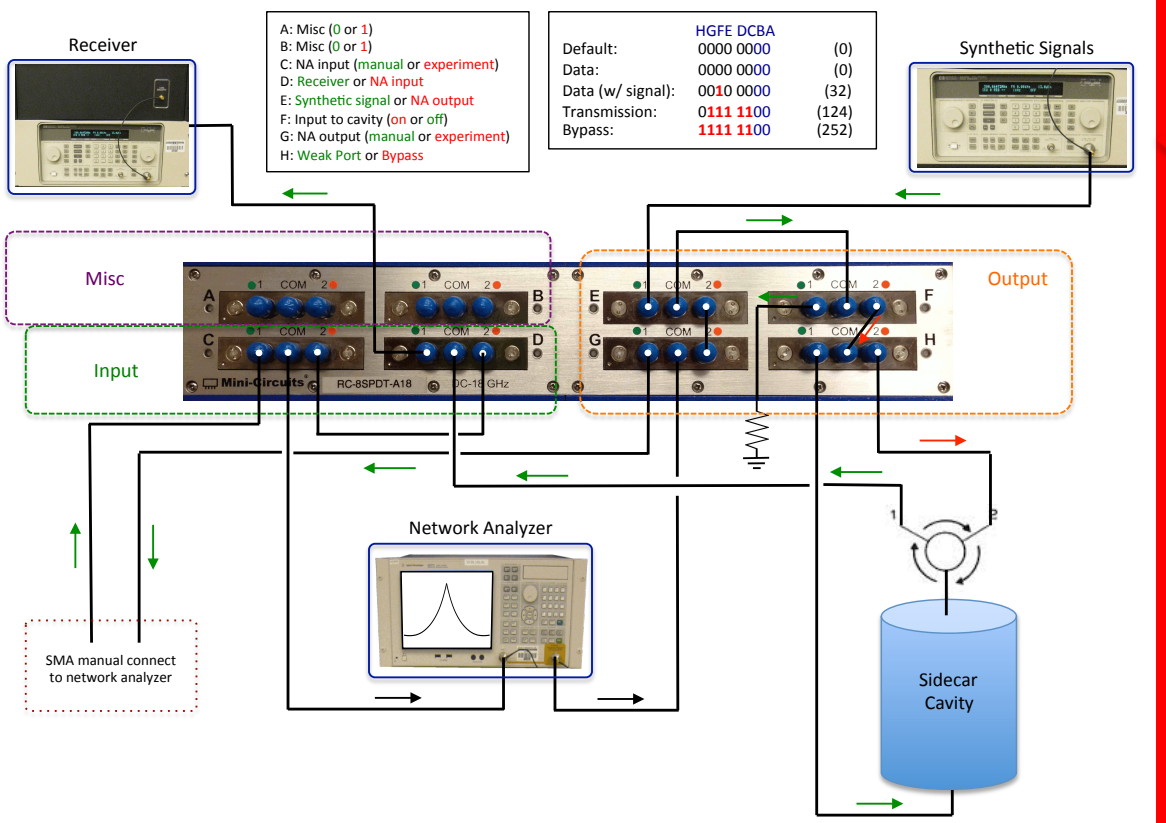

EXIT
Sidecar Modemap
Do not disturb or use sidecar components for testing
Receiver Rack in Use

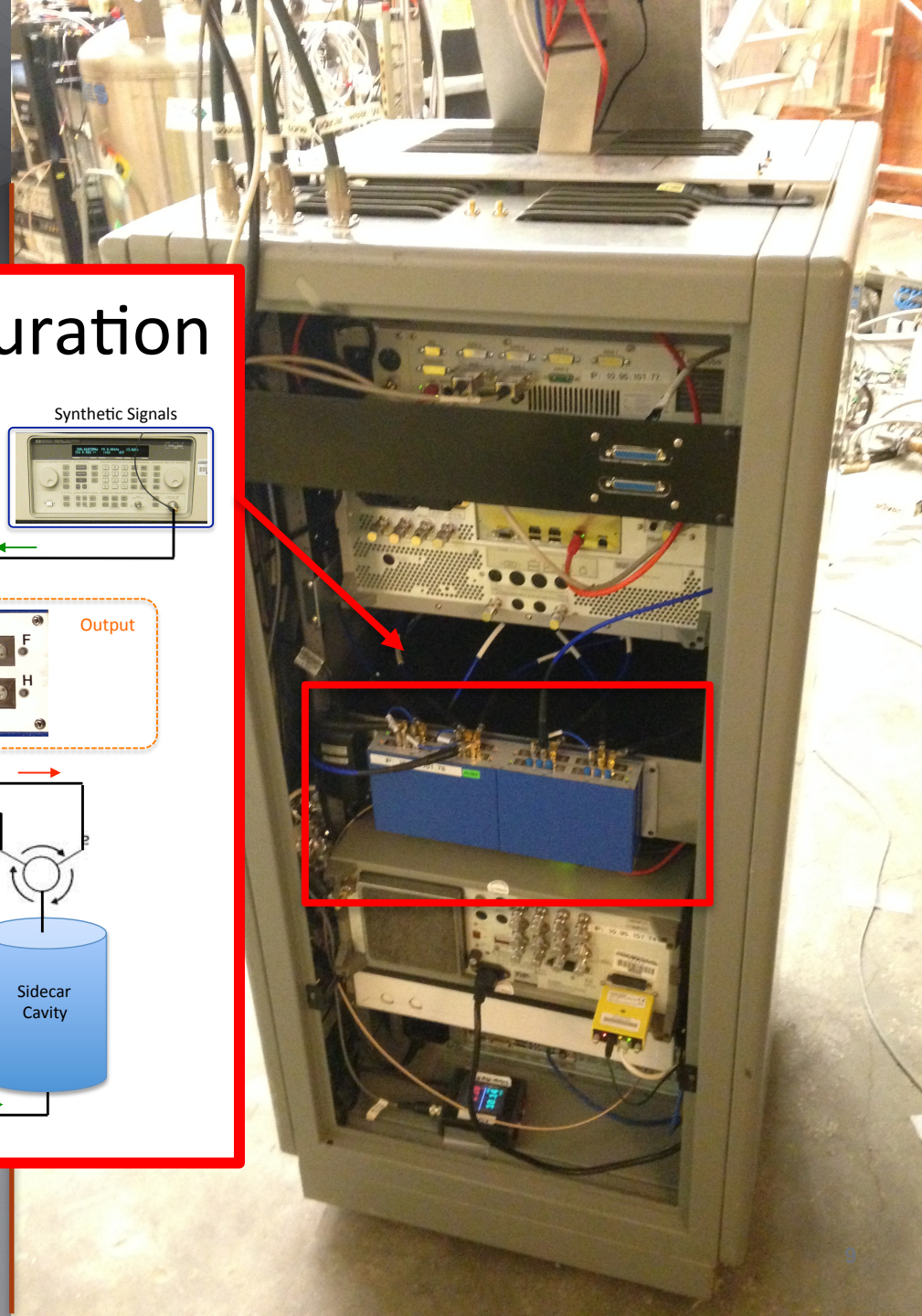

Mini-Circuits
WARRANTY VOID IF REMOVED
RF
LO
IF


Mini-Circuits
WARRANTY VOID IF REMOVED
RF
LO
IF

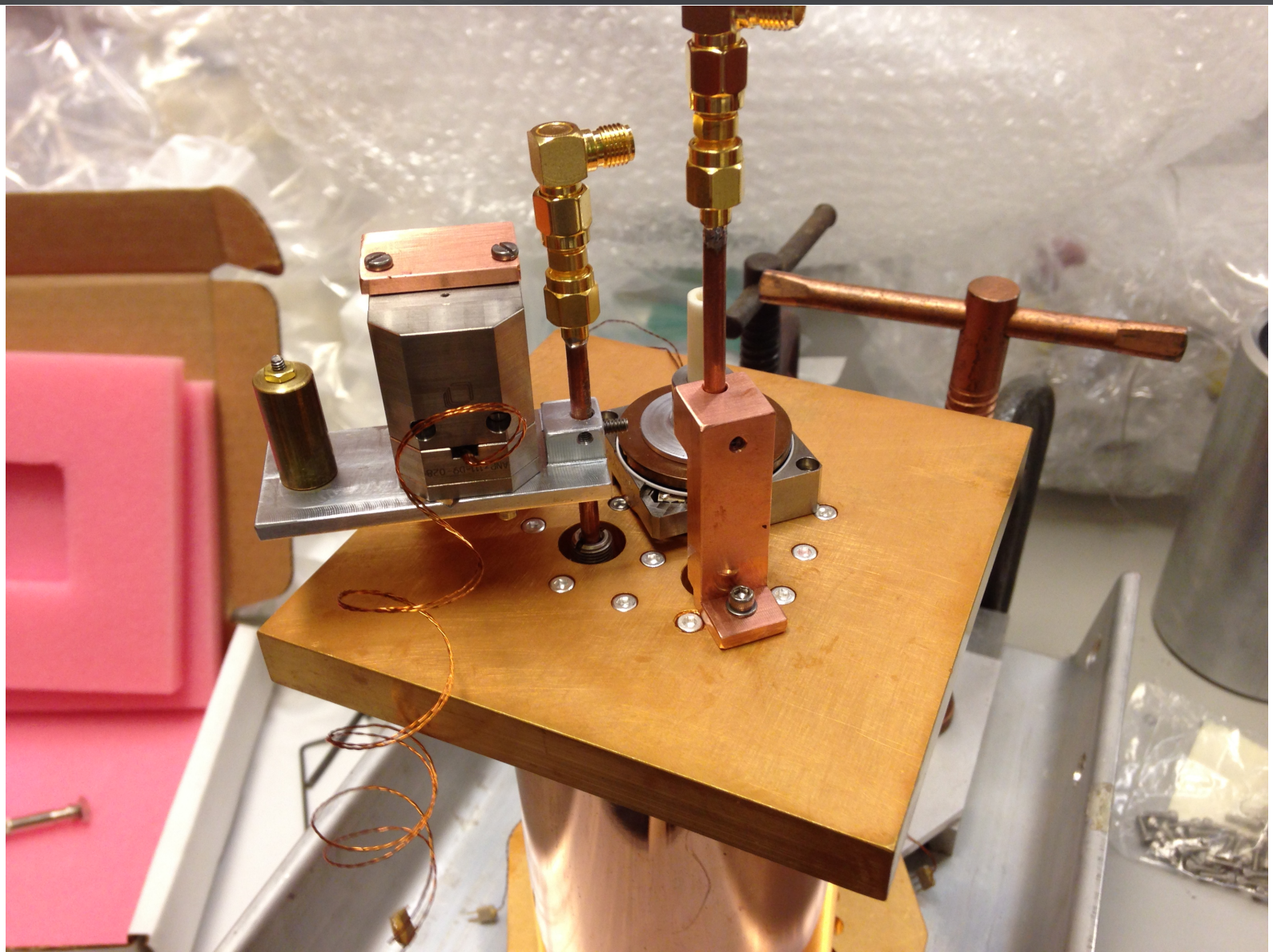
Switchbox

Sidecar Switchbox Configuration

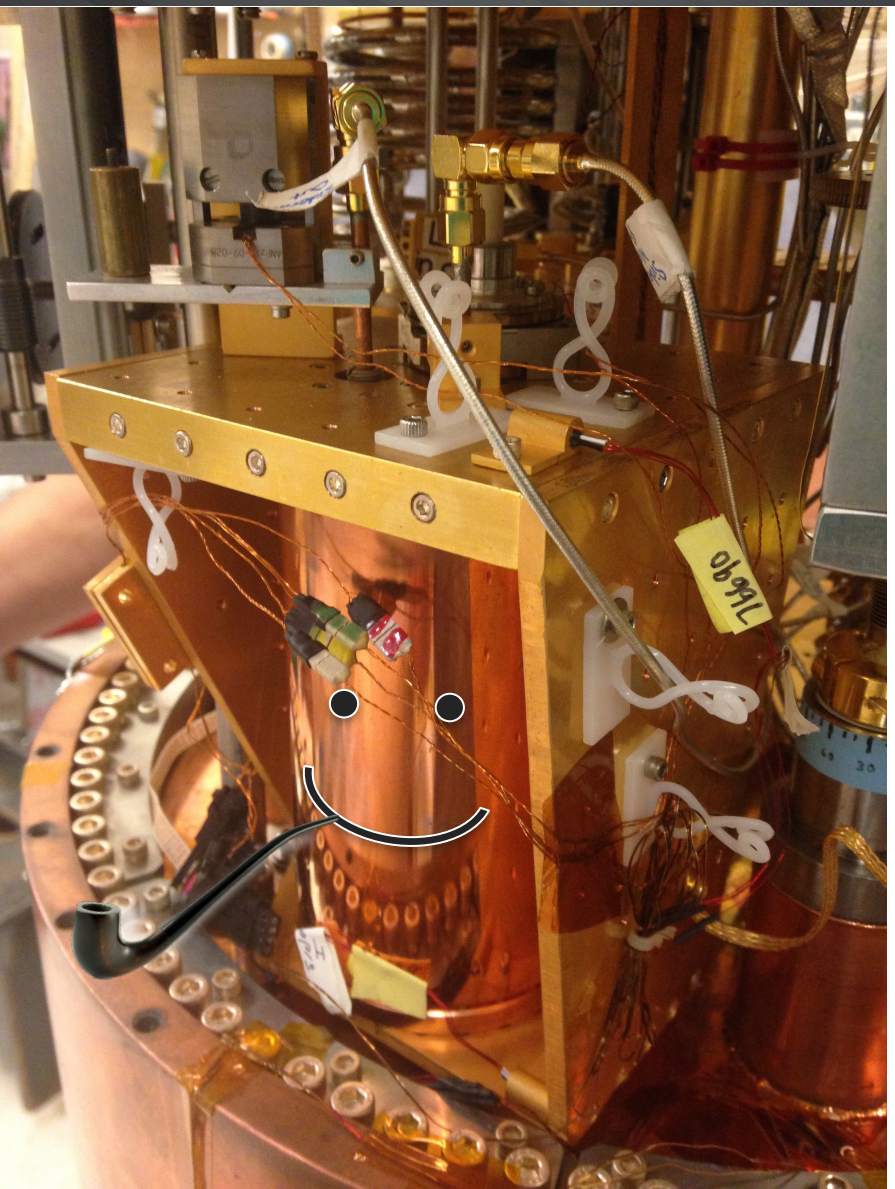


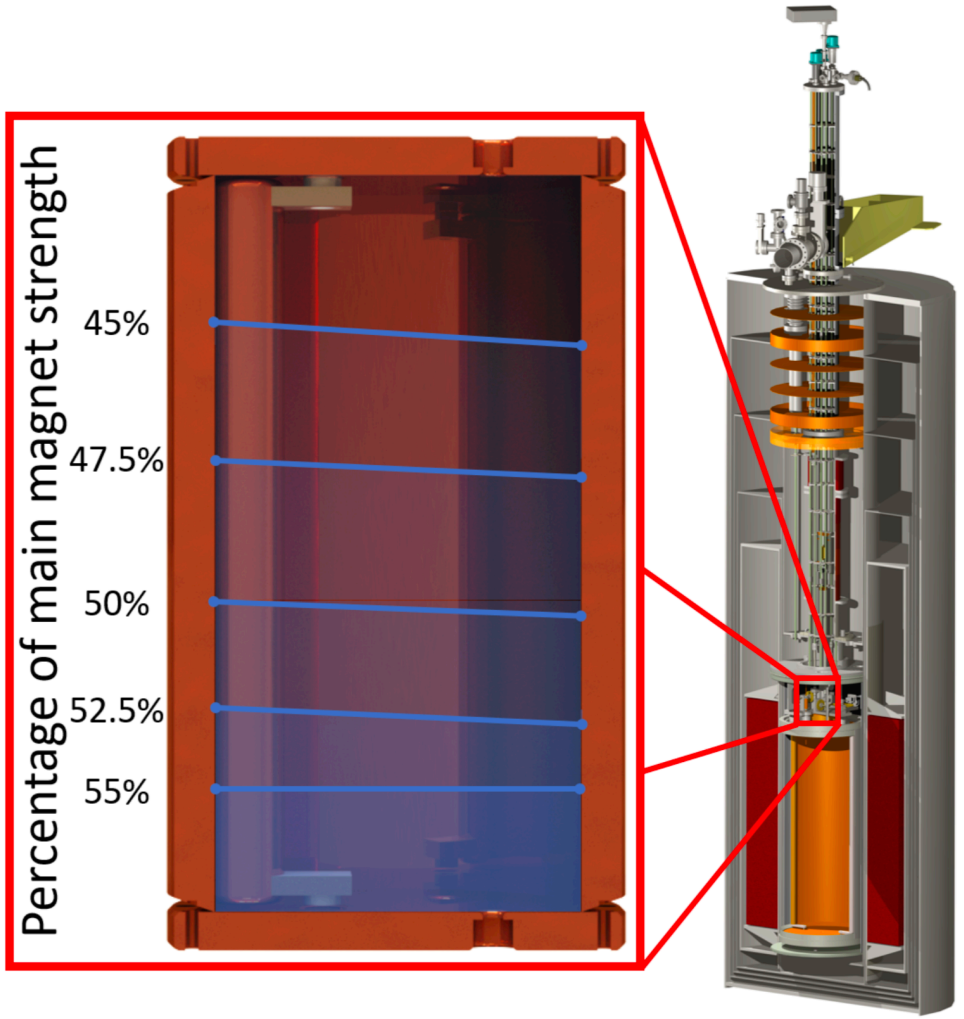


Motors Mounted on Cavity



Sidecar in Insert





Piezo Tuning + Mode Map

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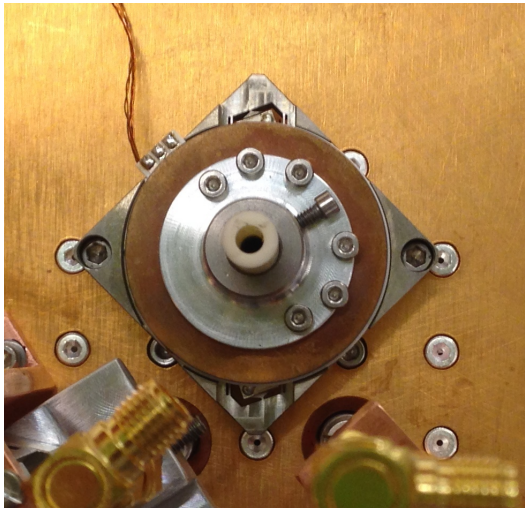
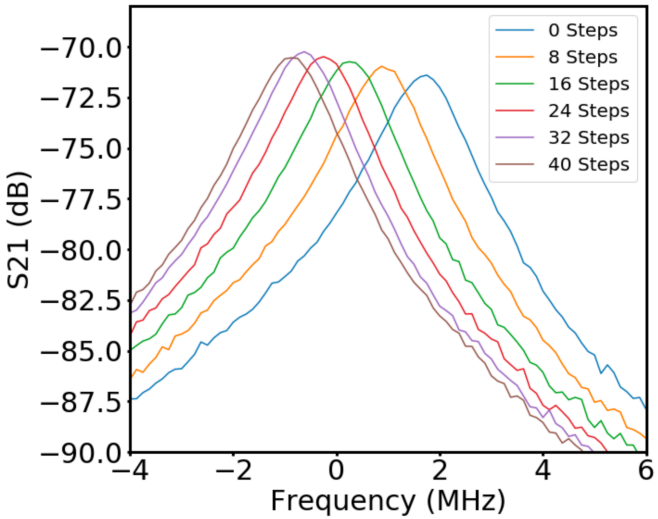
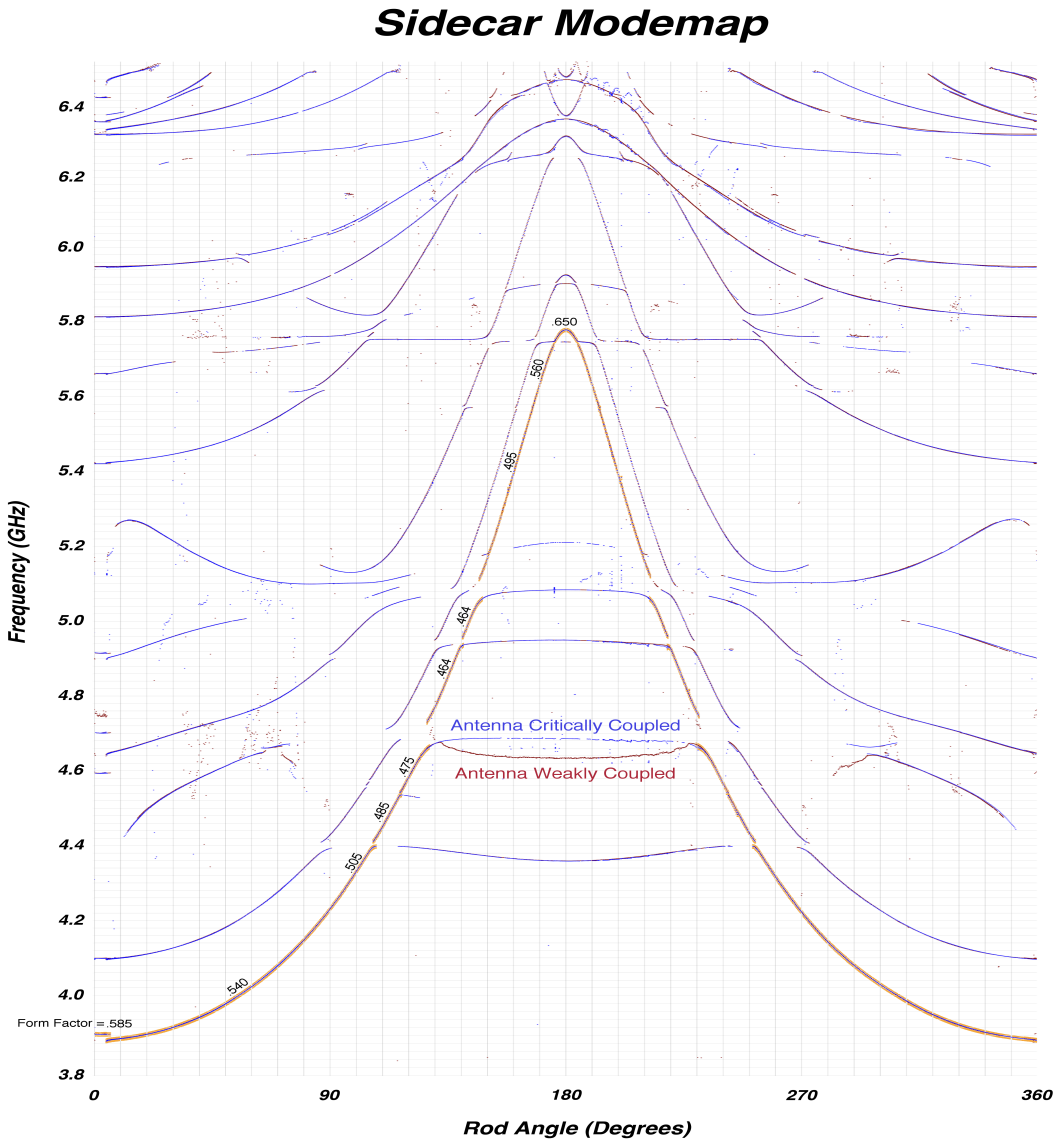
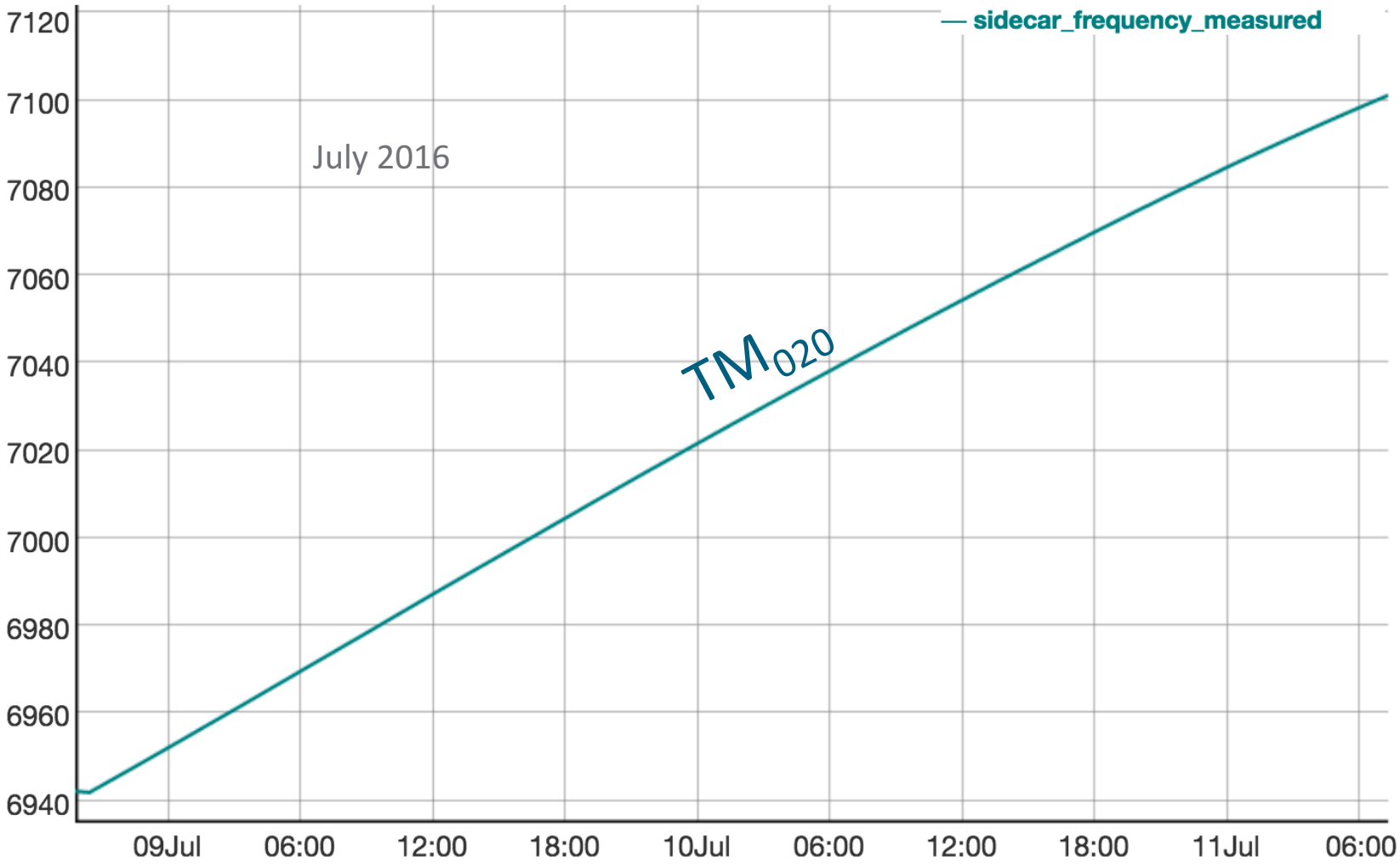






Warm Practice Data Taken on the TM_{020}

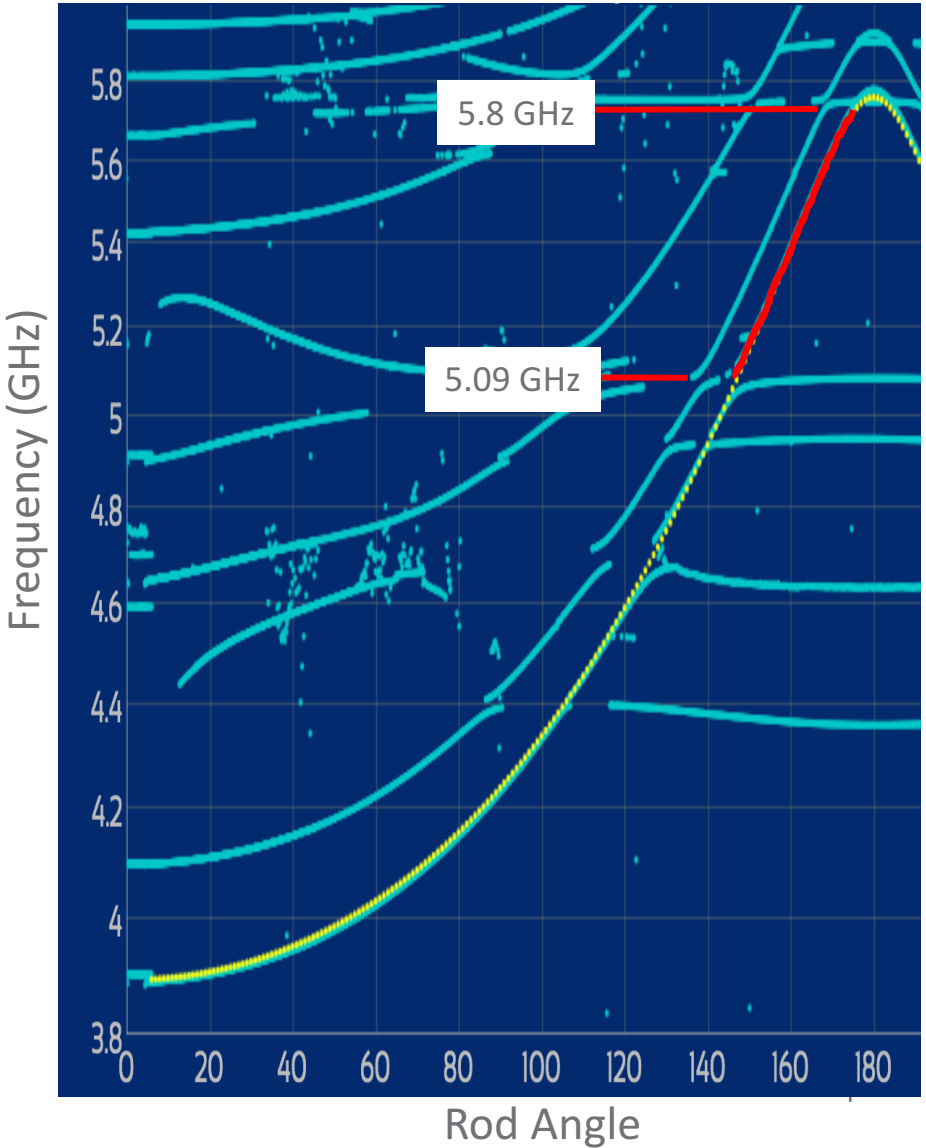


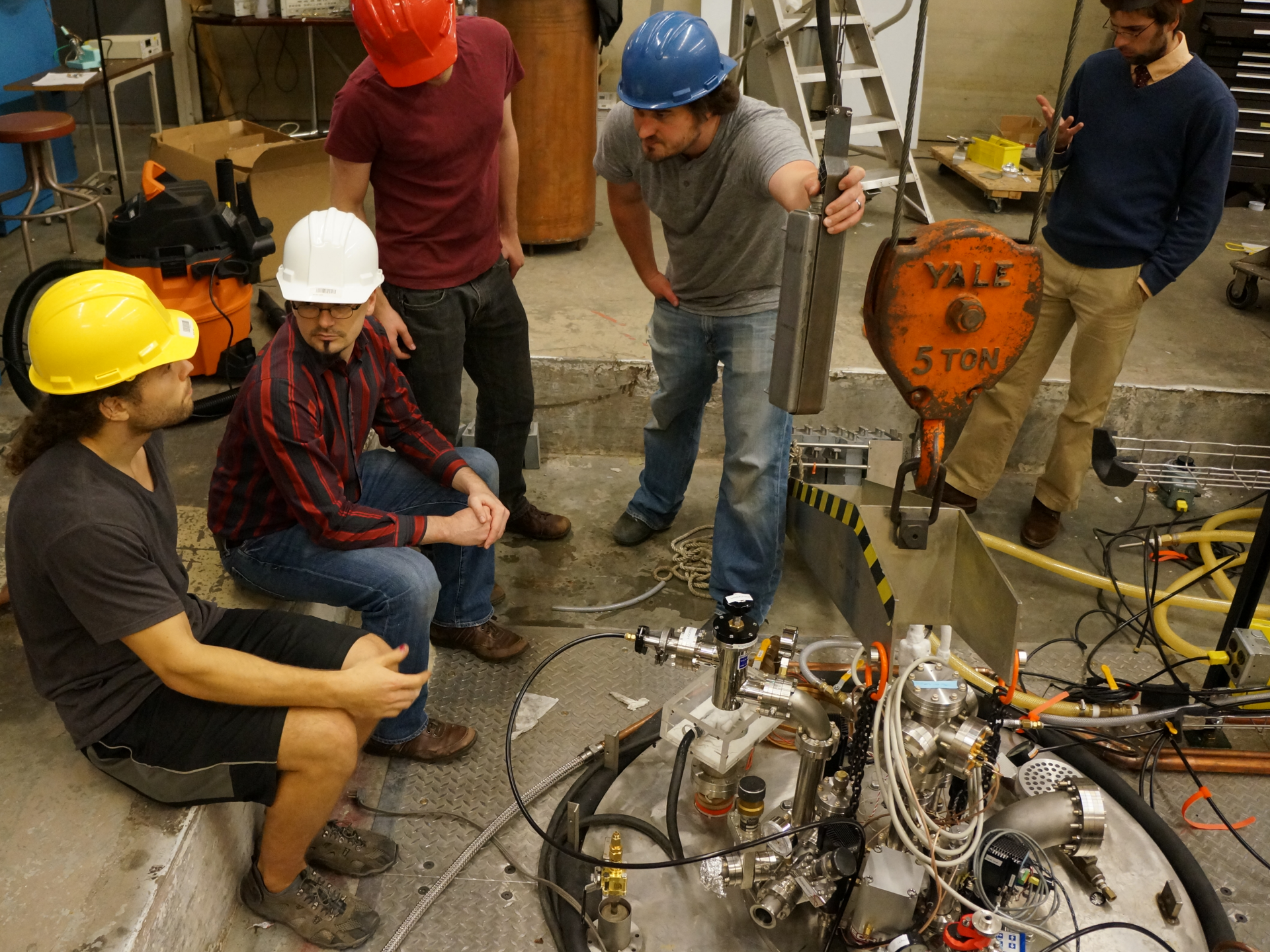
Initial Run Plan

TABLE I. Data Run Summary

Run	A	B	C
Timeline	May 24-June 11 2017	Aug 9-Oct 4 2016	Feb 27-April 9 2017
Mode	TM_{010}	TM_{010}	TM_{020}
Freq (MHz)	4,202 - 4,249	5,086 - 5,799	7,173 - 7,203
Mass (μeV)	17.38 - 17.57	21.03 - 23.98	29.67 - 29.79
Usable Spectra	14k	25k	36k
B-Field (T)	3.11	0.78 (2.55[a])	3.11
Form Factor	0.49	0.44 - 0.61	0.11 - 0.12

[a] The magnet was ramped to a higher field for 3 days just before the end of the data run




YALE
5 TON

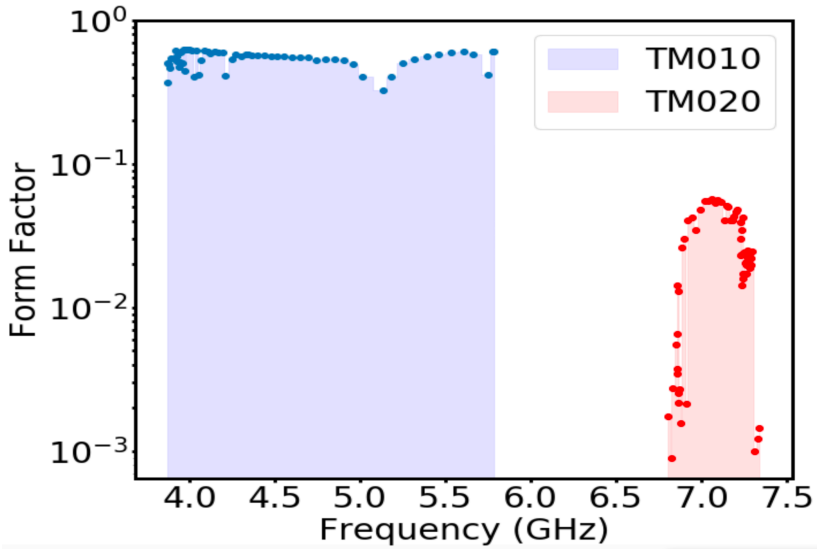
The

Insert

was

removed

Run Plan (TM_{020})



Run	A	B	C
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Mode	TM_{010}	TM_{010}	TM_{020}
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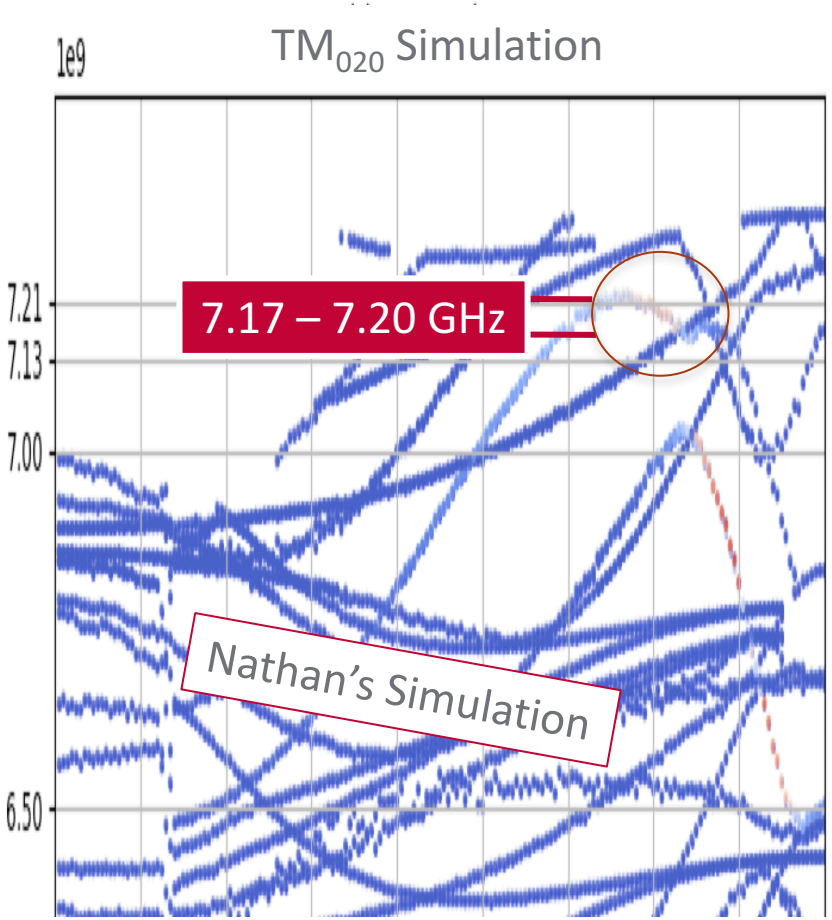
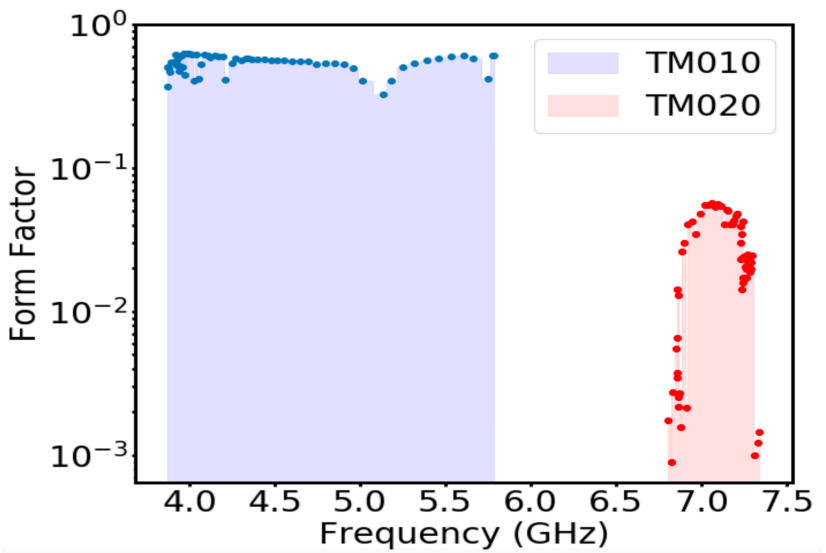


Rod Angle

Run Plan (TM_{010})



Run	A	B	C
Timeline	May 24-June 11 2017	Aug 9-Oct 4 2016	Feb 27-April 9 2017
Mode	TM_{010}	TM_{010}	TM_{020}
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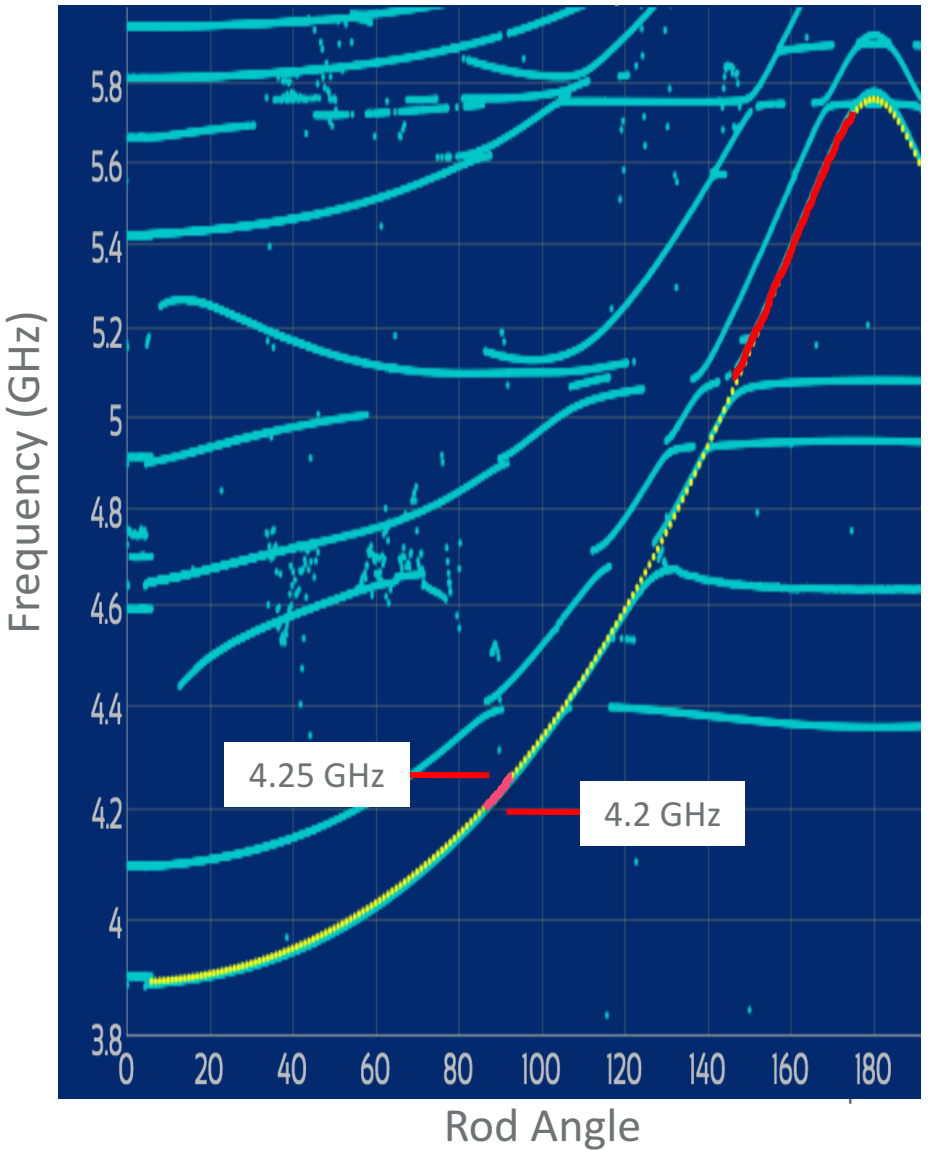
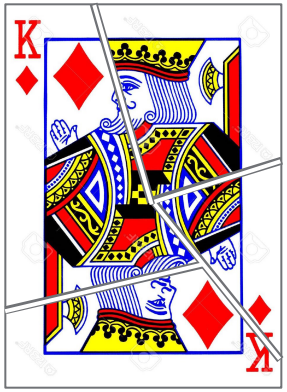


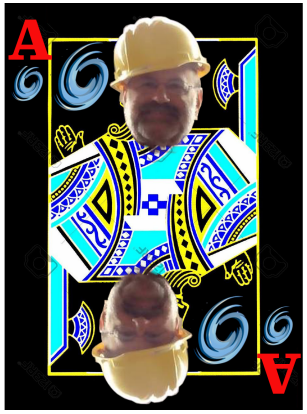
Analysis

Analysis Block Diagram



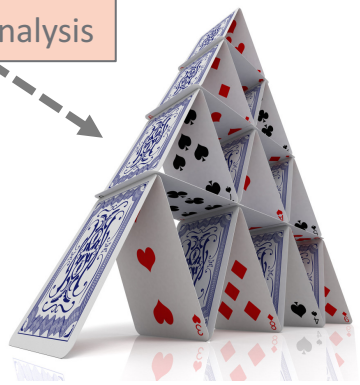
Get/re-package next scan

Single Scan Analysis

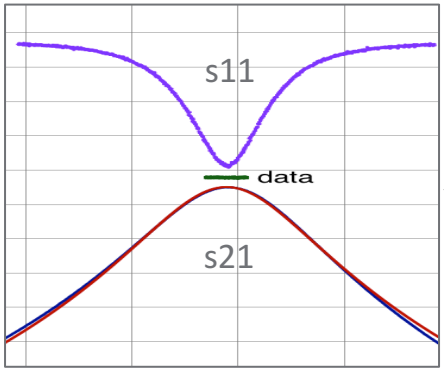


Quality Cuts

Grand Analysis



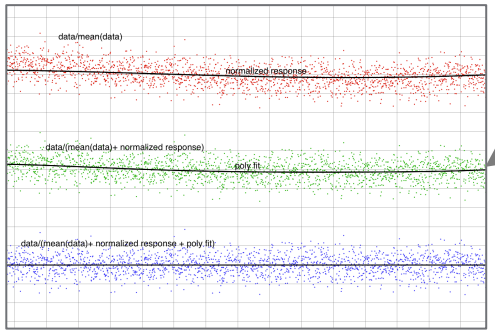
Analysis Block Diagram



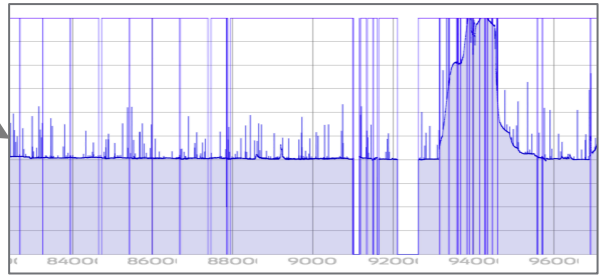
sql database

Get/re-package next scan

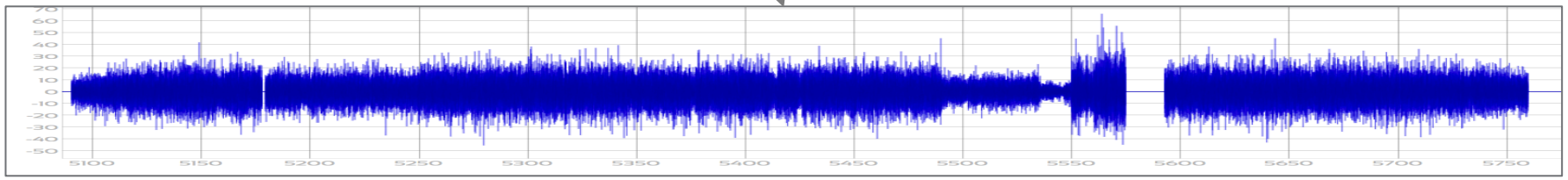
Single Scan Analysis



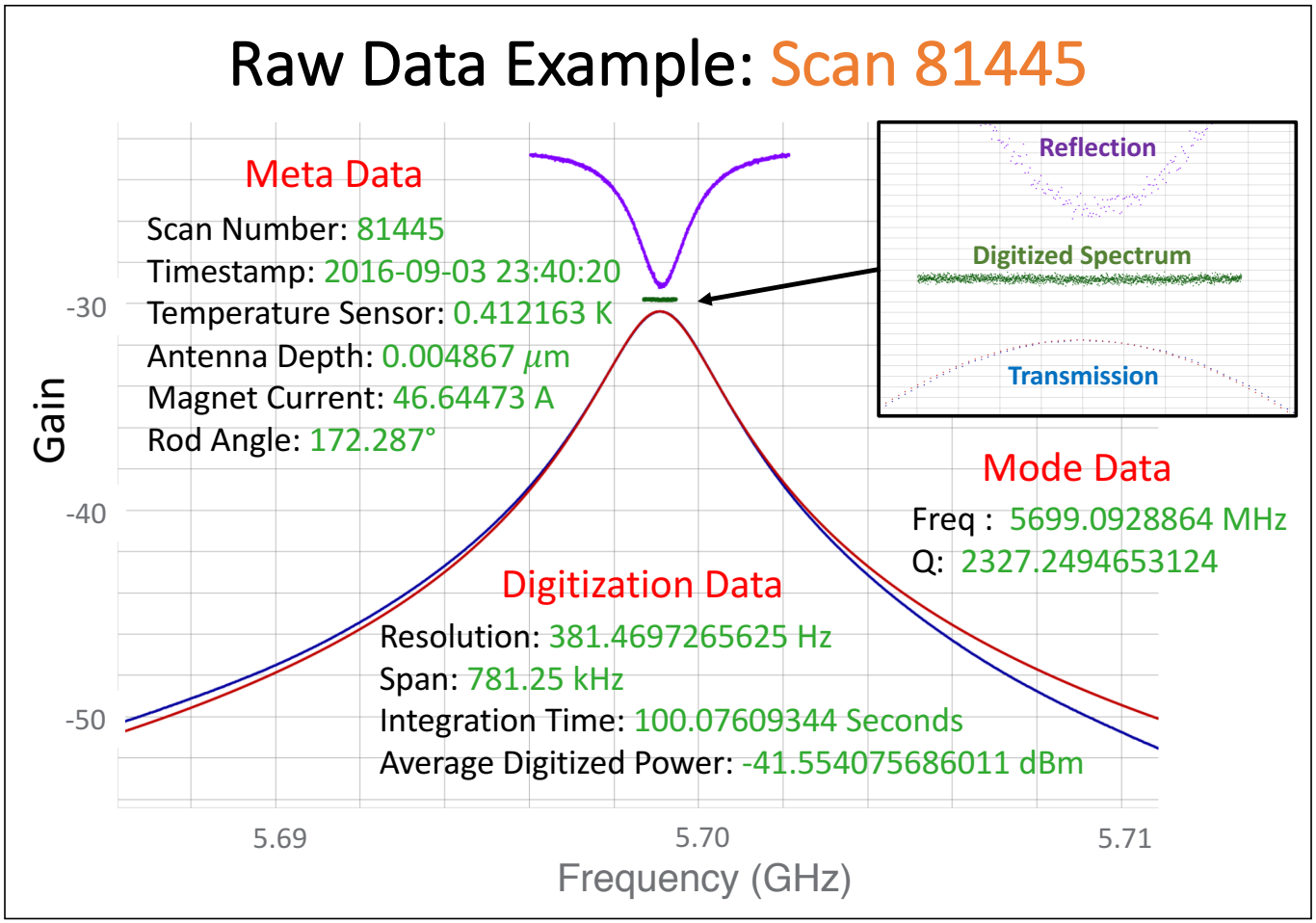
Quality Cuts

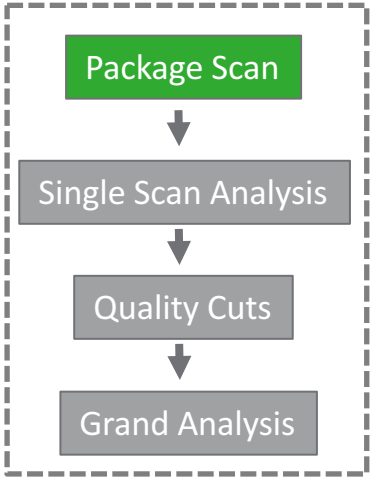


Grand Analysis

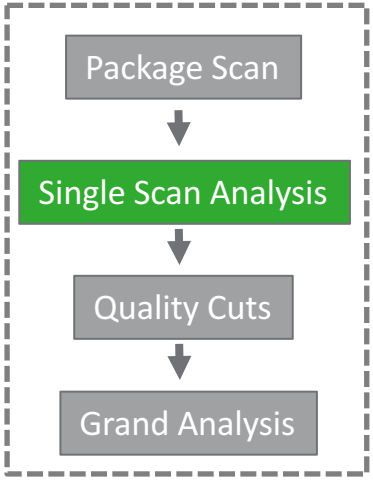


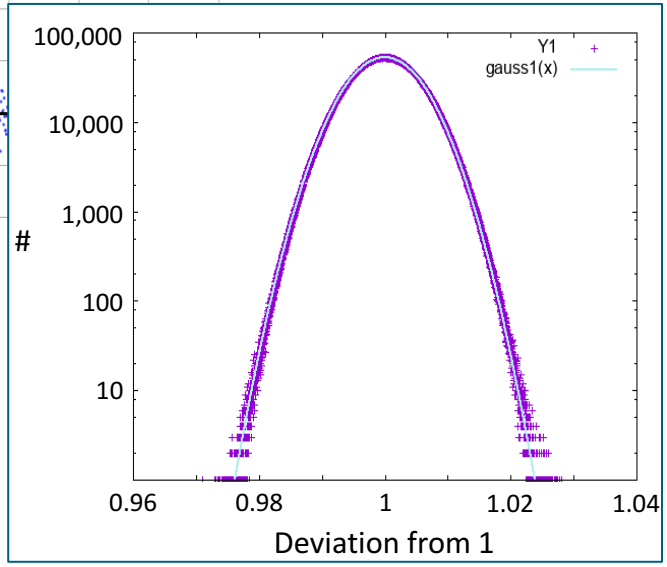
Raw Data Example: Scan 81445





Single Scan Analysis:
Remove Receiver Response





Single Scan Analysis: Expected Power

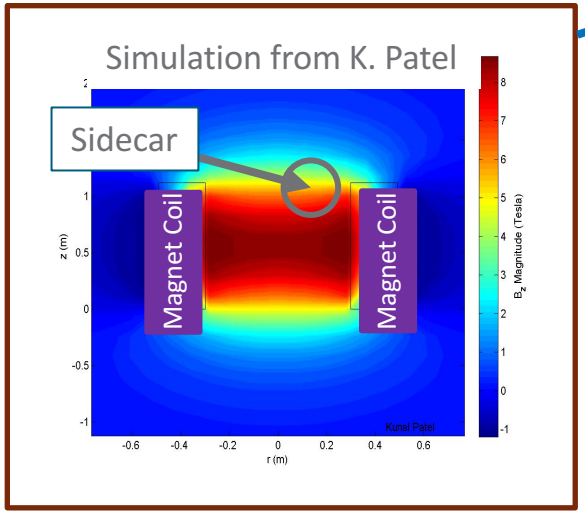
Set by nature

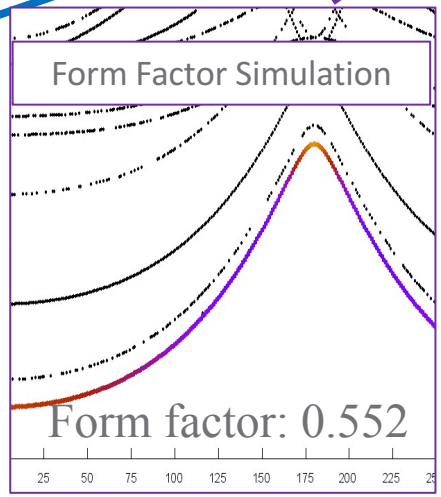
Already Measured

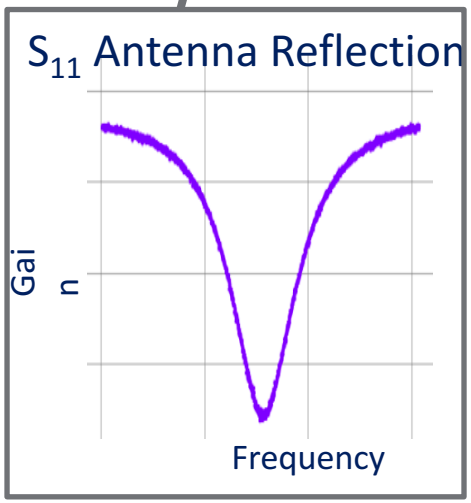
Calculated

Measured with injected signals

$$P^{expected} \propto (g_\gamma^2 \rho_a)(V f Q_L)(B^2 f_{mnl} \boldsymbol{\kappa} \frac{1}{1+4Q^2(\frac{f}{f_0}-1)^2})(\boldsymbol{\eta})$$

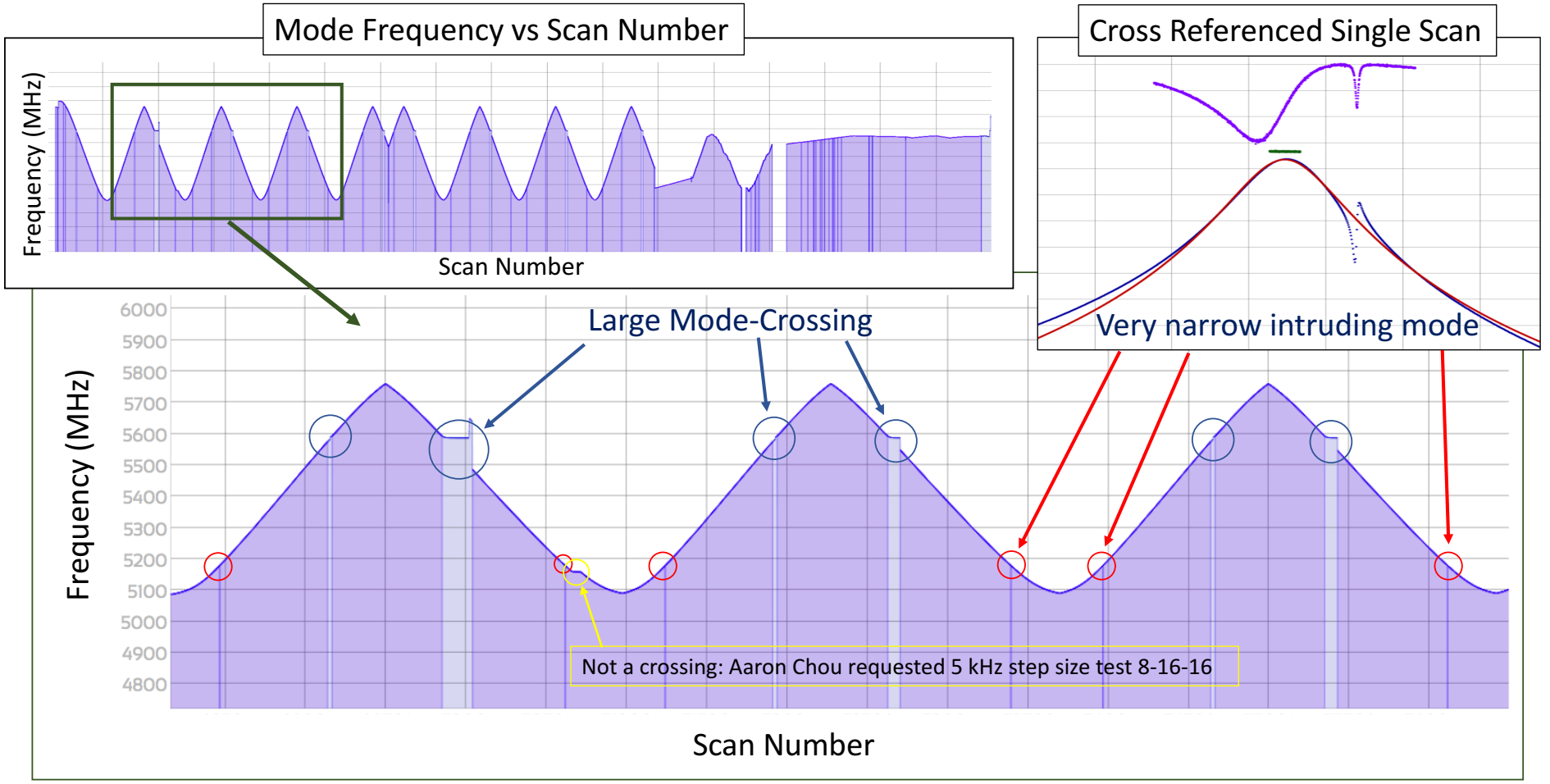




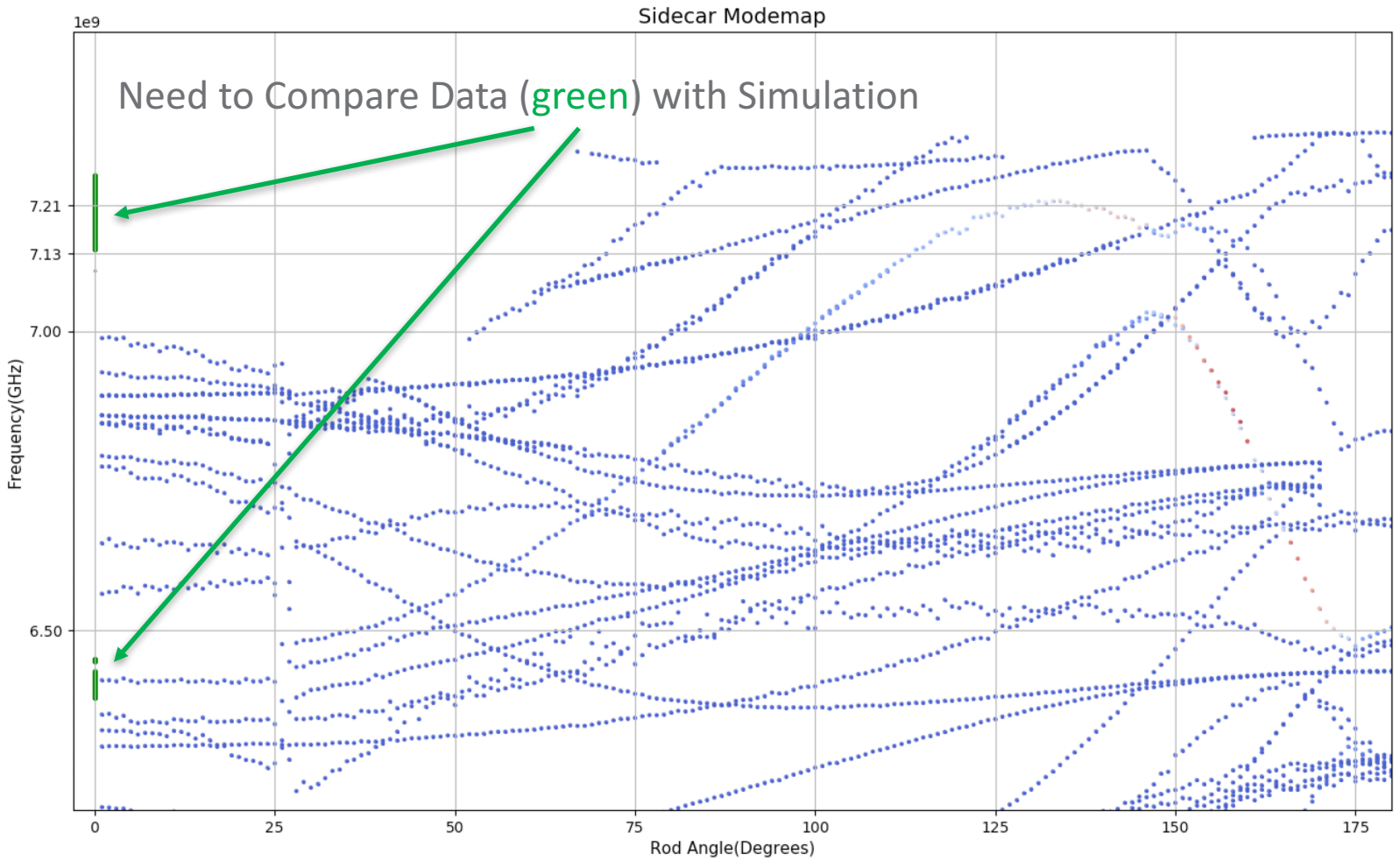


Signal Propagation Efficiency: determined by software signal injections through the entire pipeline

Quality Control: Manual Cuts



Encoders were Unplugged during TM_{020} Run



Data assigned approximate rod positions based on commands sent to the piezo controller

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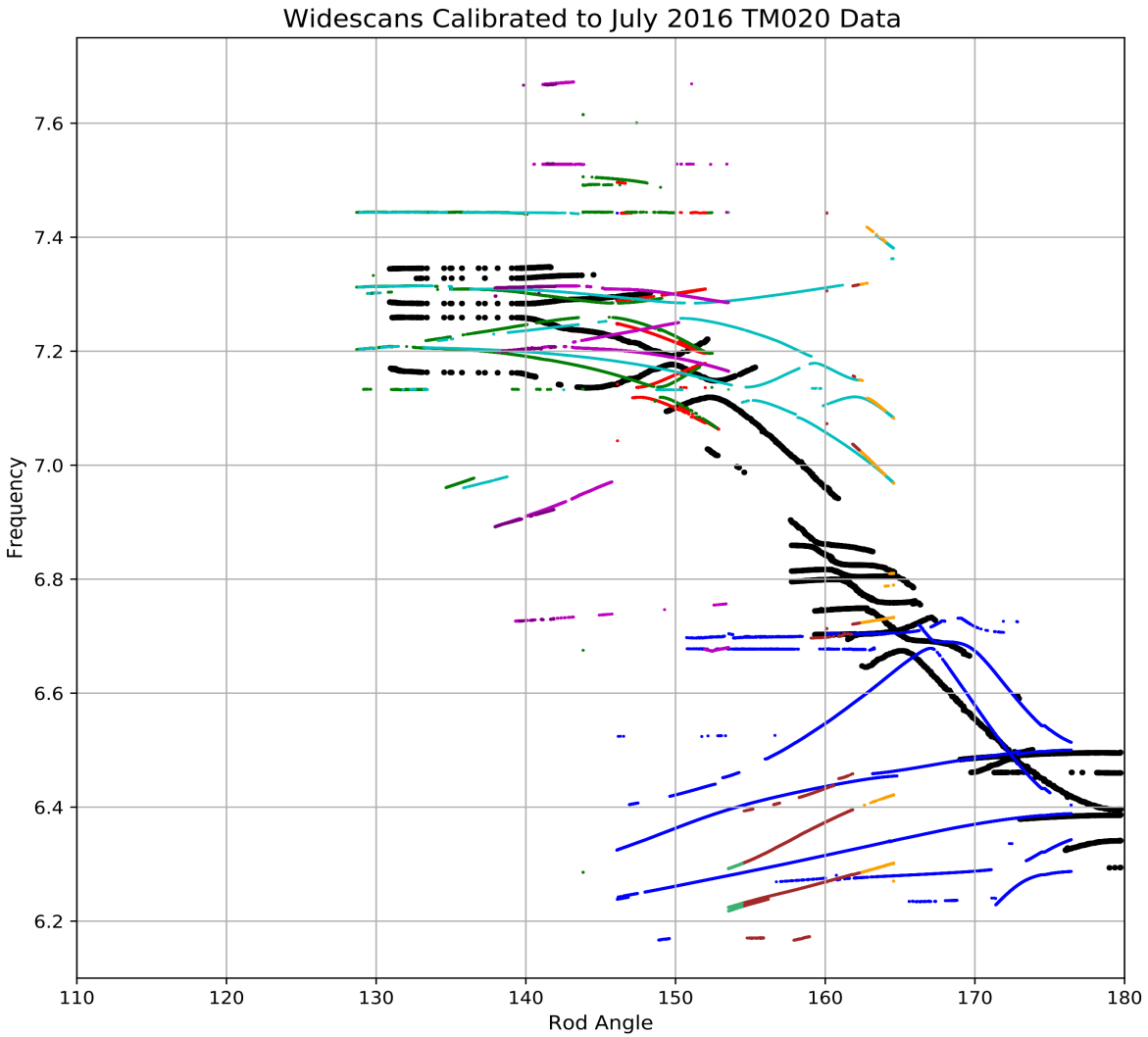

Data from different timestamps allowed to compress or expand to match reference map

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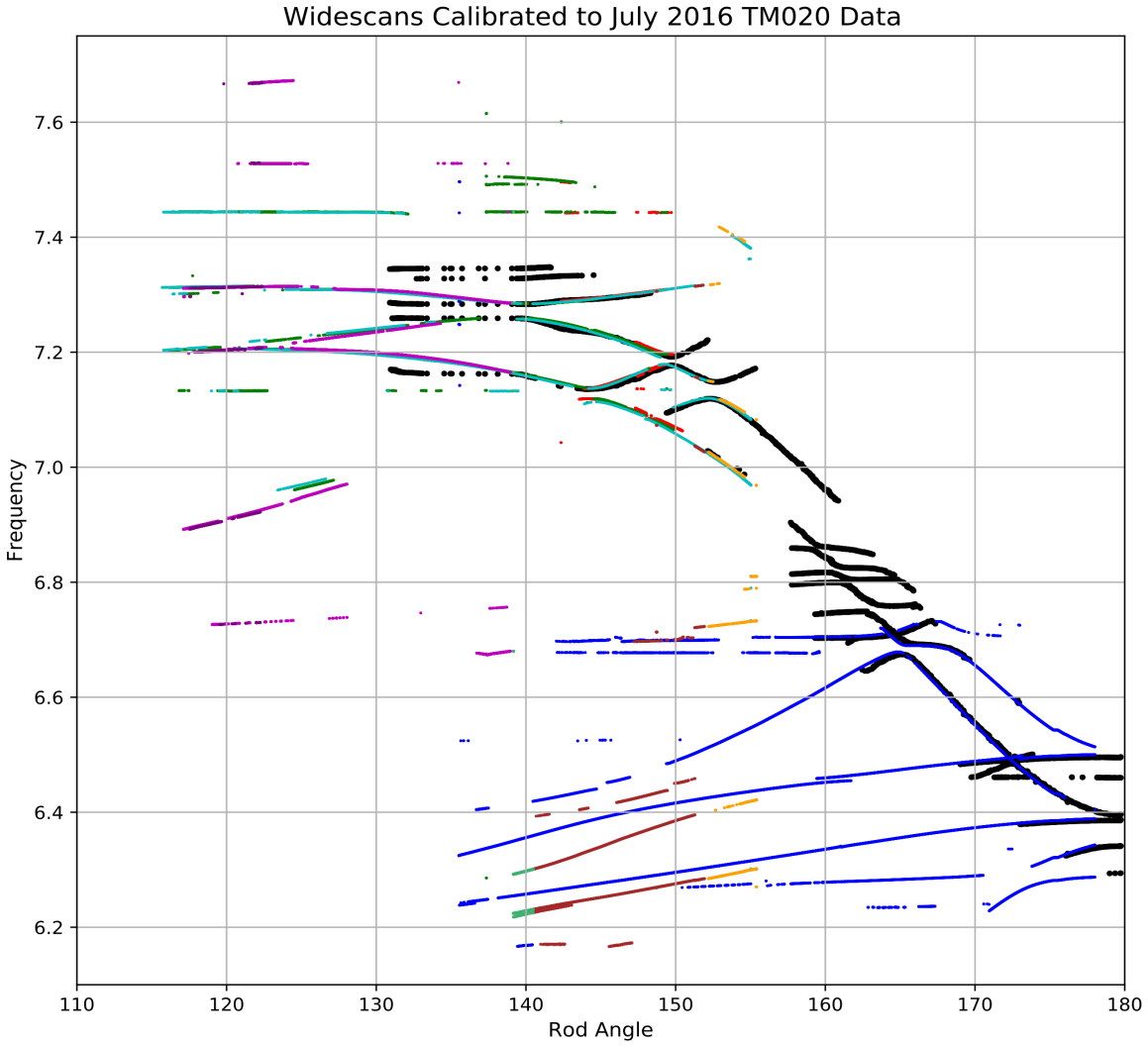
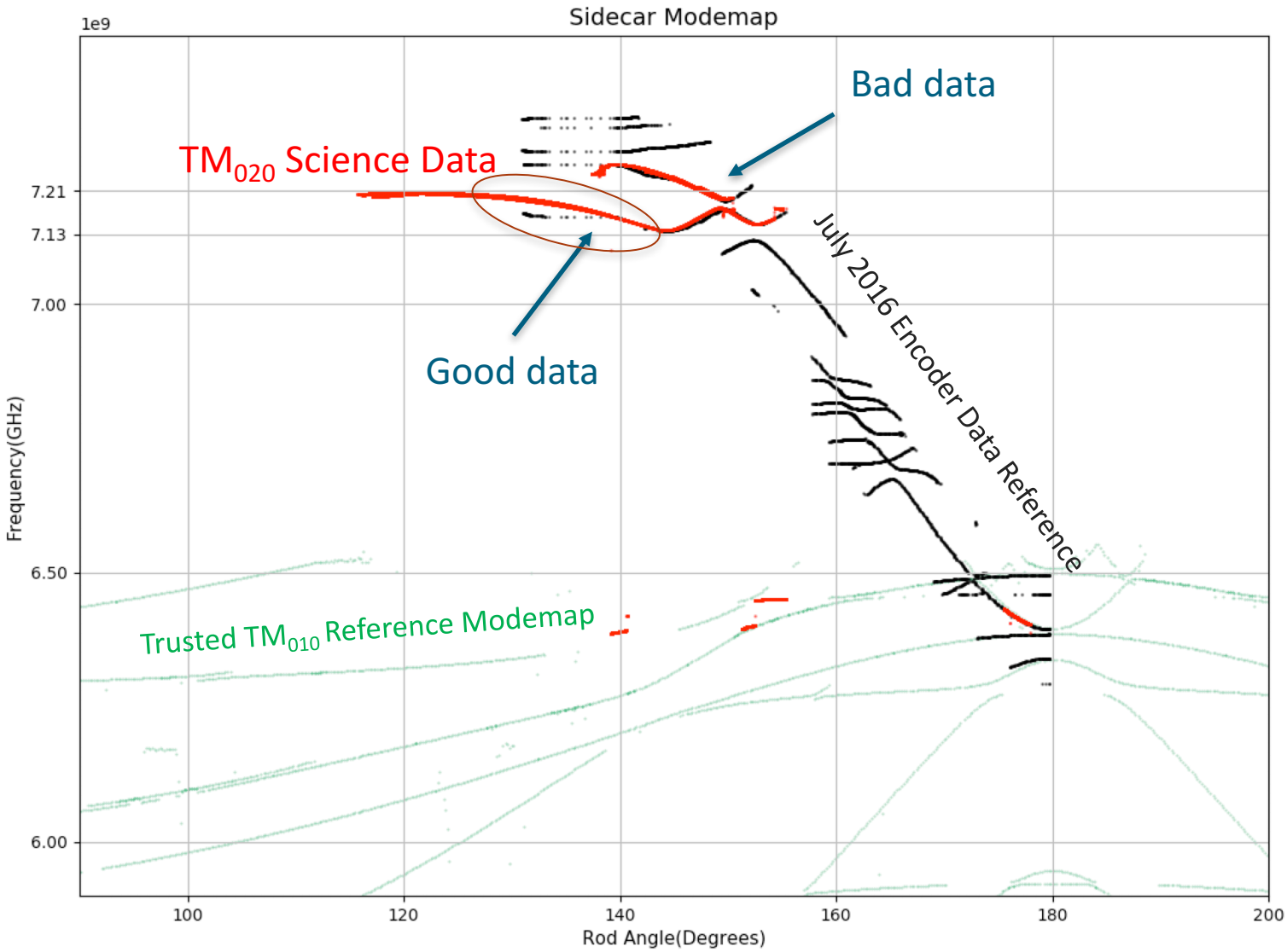


TM_{020} Science Data



Submitted Paper to PRL Yesterday

Piezoelectrically Tuned, Multi-mode Cavity Search for Axion Dark Matter

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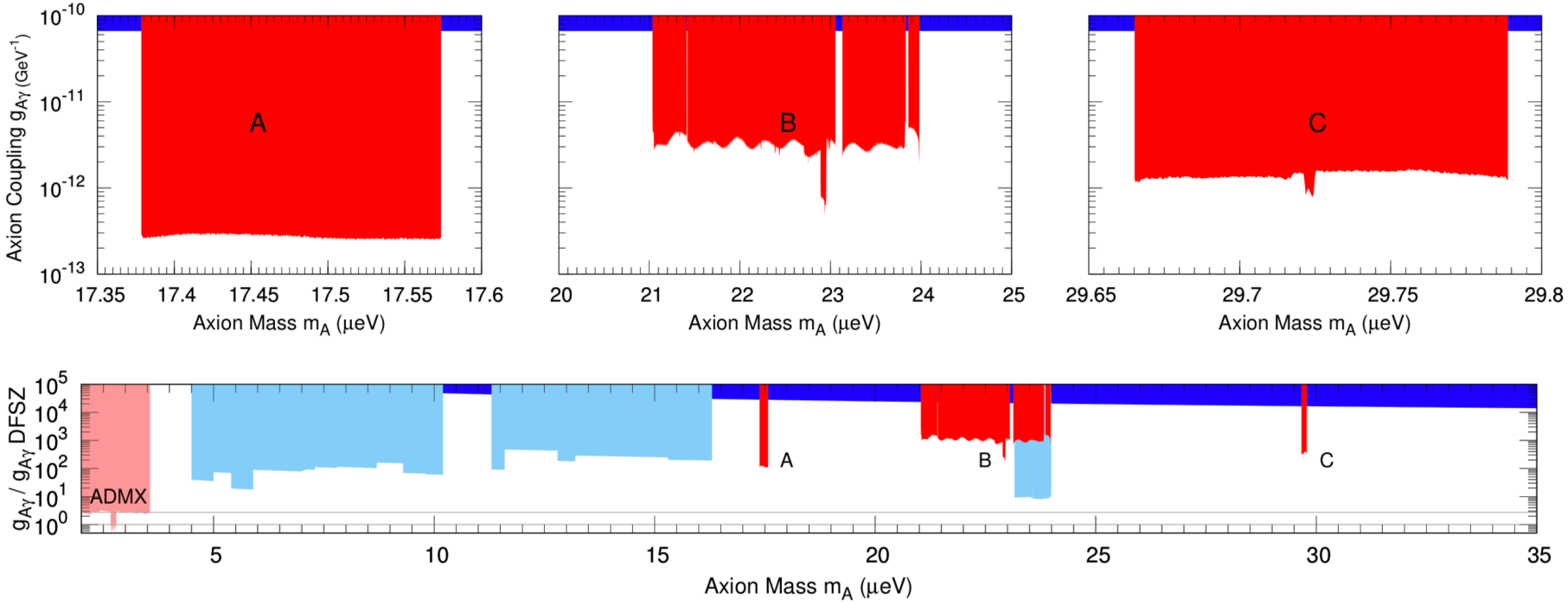
E. Lentz
University of Göttingen, Göttingen, Germany

(ADMX Collaboration)

(Dated: August 16, 2018)

The μeV axion is a well-motivated extension to the standard model. The Axion Dark Matter eXperiment (ADMX) collaboration seeks to discover this particle by looking for the resonant conversion of dark-matter axions to microwave photons in a strong magnetic field. In this paper we report results from an ADMX pathfinder experiment, the ADMX "Sidecar", which is designed to pave the way for future, higher mass, searches. The Sidecar experiment excludes masses in three widely spaced frequency ranges (4202-4249 MHz, 5086-5799 MHz and 7173-7203 MHz), corresponding to masses favored by some cosmic string simulations. In addition, Sidecar demonstrates the successful use of piezoelectric actuators for both cavity tuning and antenna coupling. Finally, this publication is the first to report data taken on both the TM_{010} and TM_{020} modes.

Limits


Axion Coupling $g_{A\gamma}$ (GeV^{-1})
10^{-10}
10^{-11}
10^{-12}
10^{-13}
A
B
C
17.35
17.4
17.45
17.5
17.55
17.6
20
21
22
23
24
25
29.65
29.7
29.75
29.8
Axion Mass m_A (μeV)
$g_{A\gamma}$ / $g_{A\gamma}$ DFSZ
10^5
10^4
10^3
10^2
10^1
10^0
ADMX
A
B
C
5
10
15
20
25
30
35
Axion Mass m_A (μeV)

Next Up:

Stay tuned for Nathan's

Future of Sidecar

Talk


ADMX
The End