# Results from the ADMX G2 Experiment

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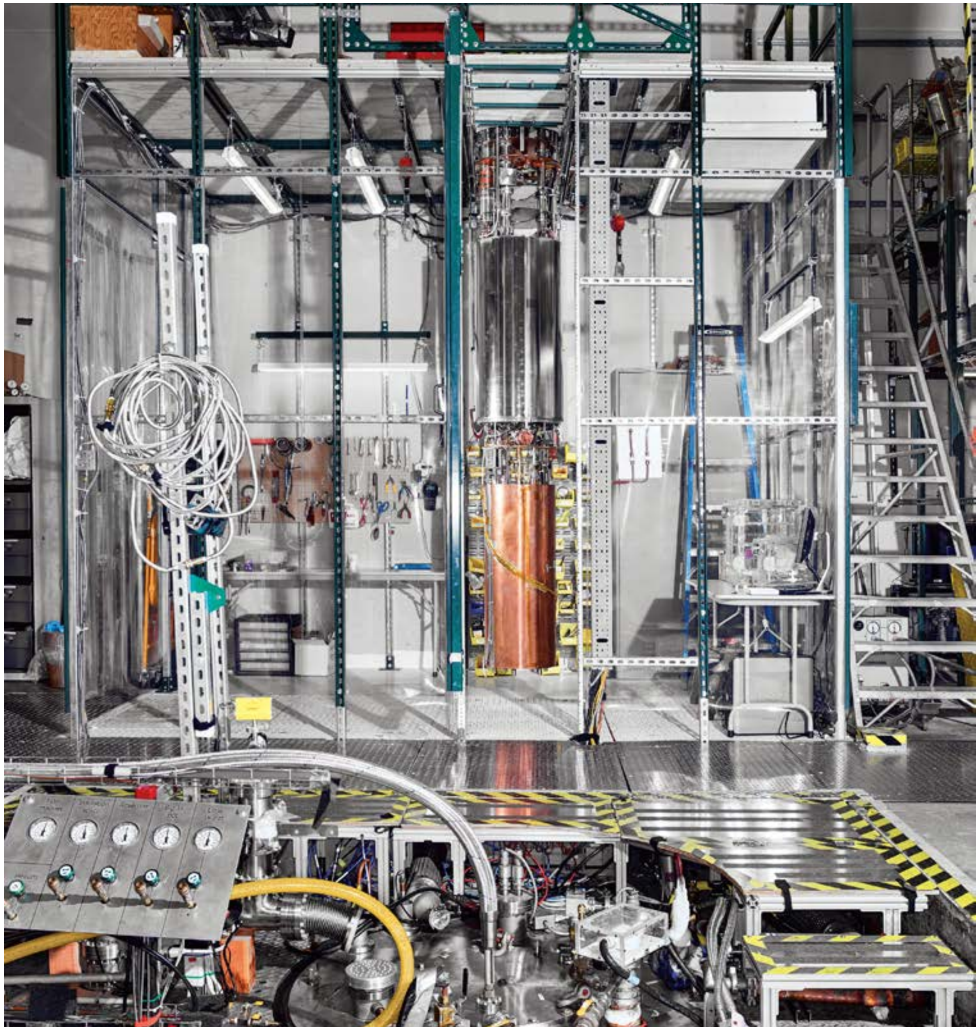
University of Washington

3rd Workshop of Microwave Cavities and Detectors for Axion Research

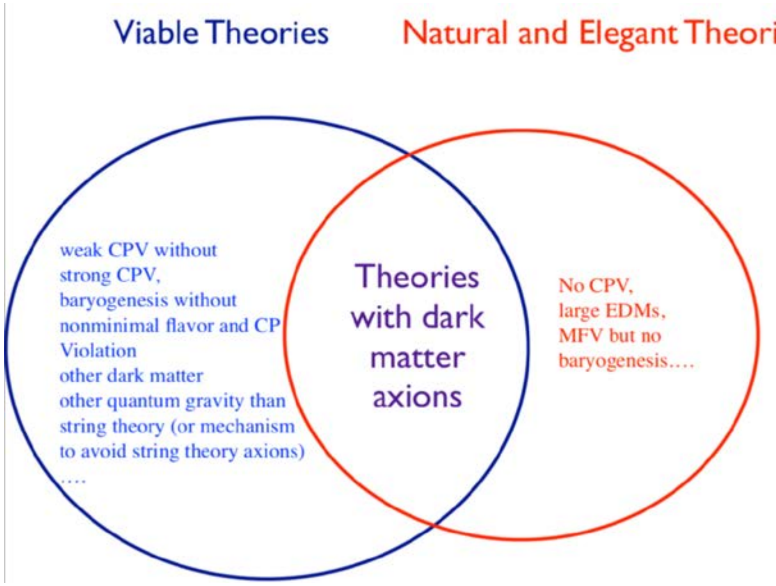
August 21, 2018



# Why axions?

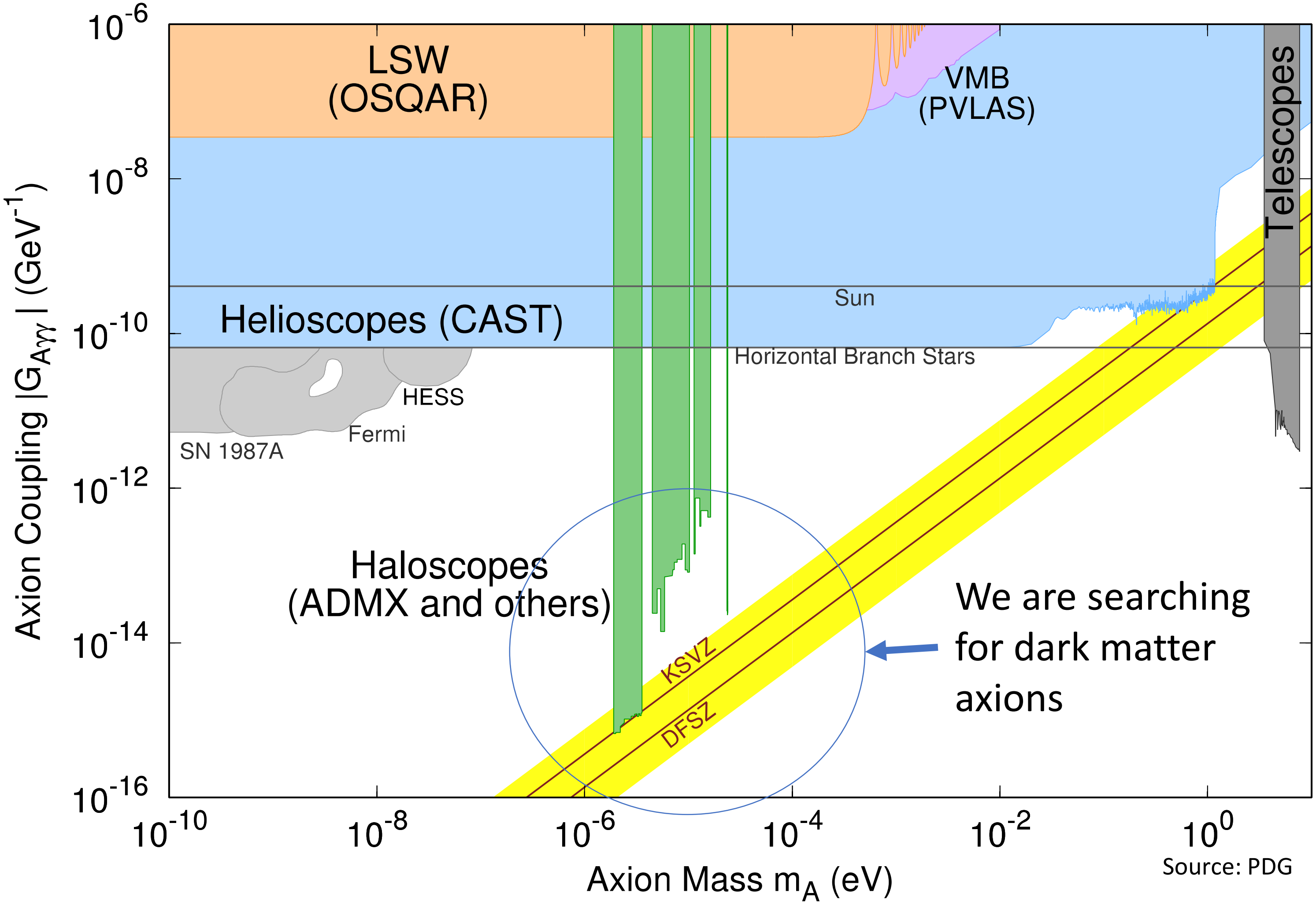
ADMX AXION DARK MATTER EXPERIMENT

- Axions are a hypothetical particle developed to solve the strong CP problem
- Among other things, their feeble interactions make them an ideal dark matter candidate




*Source: Ann Nelson, Vistas in Axion Physics 2012*

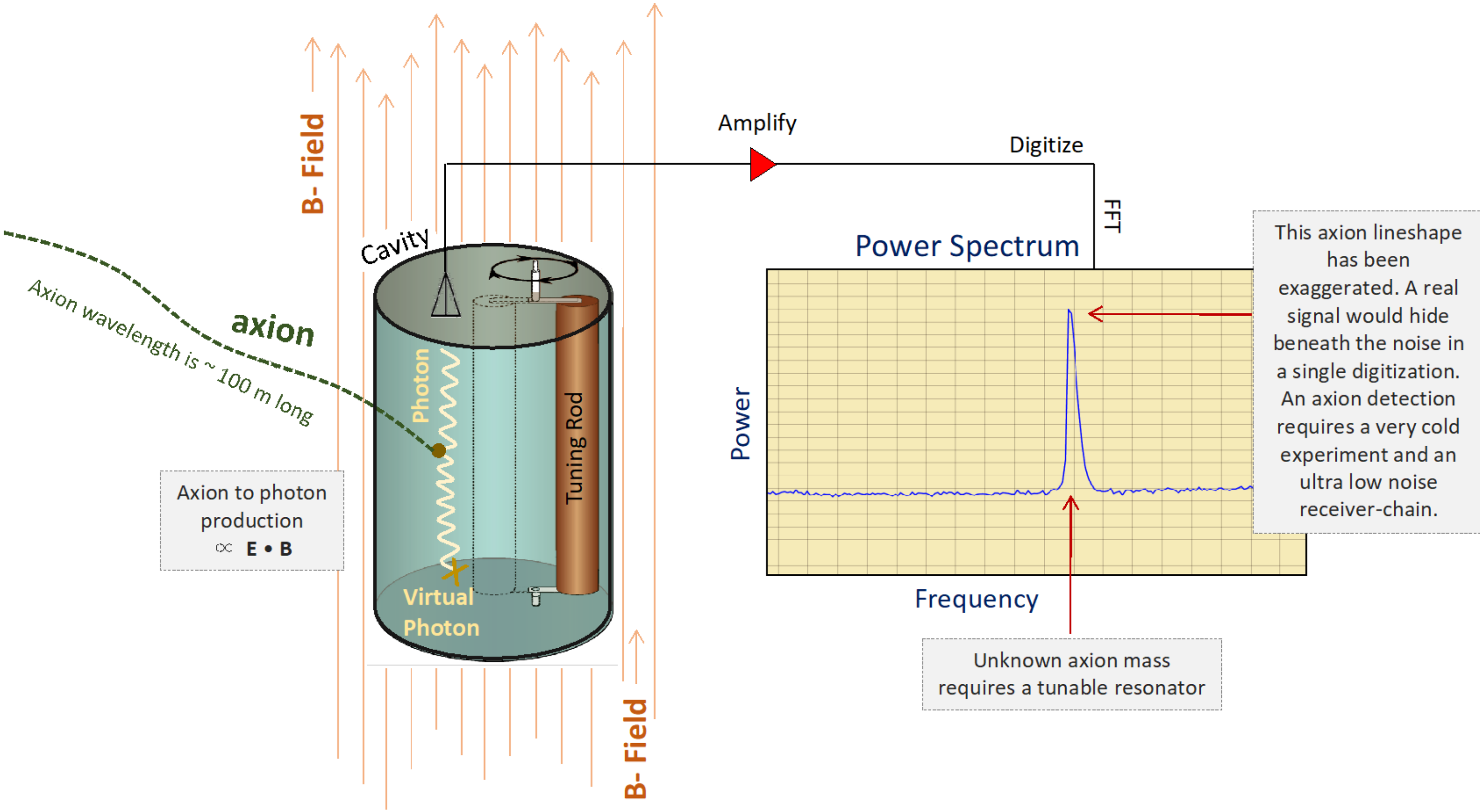
# Axion Parameter Space




Source: PDG

# Dark Matter Detection

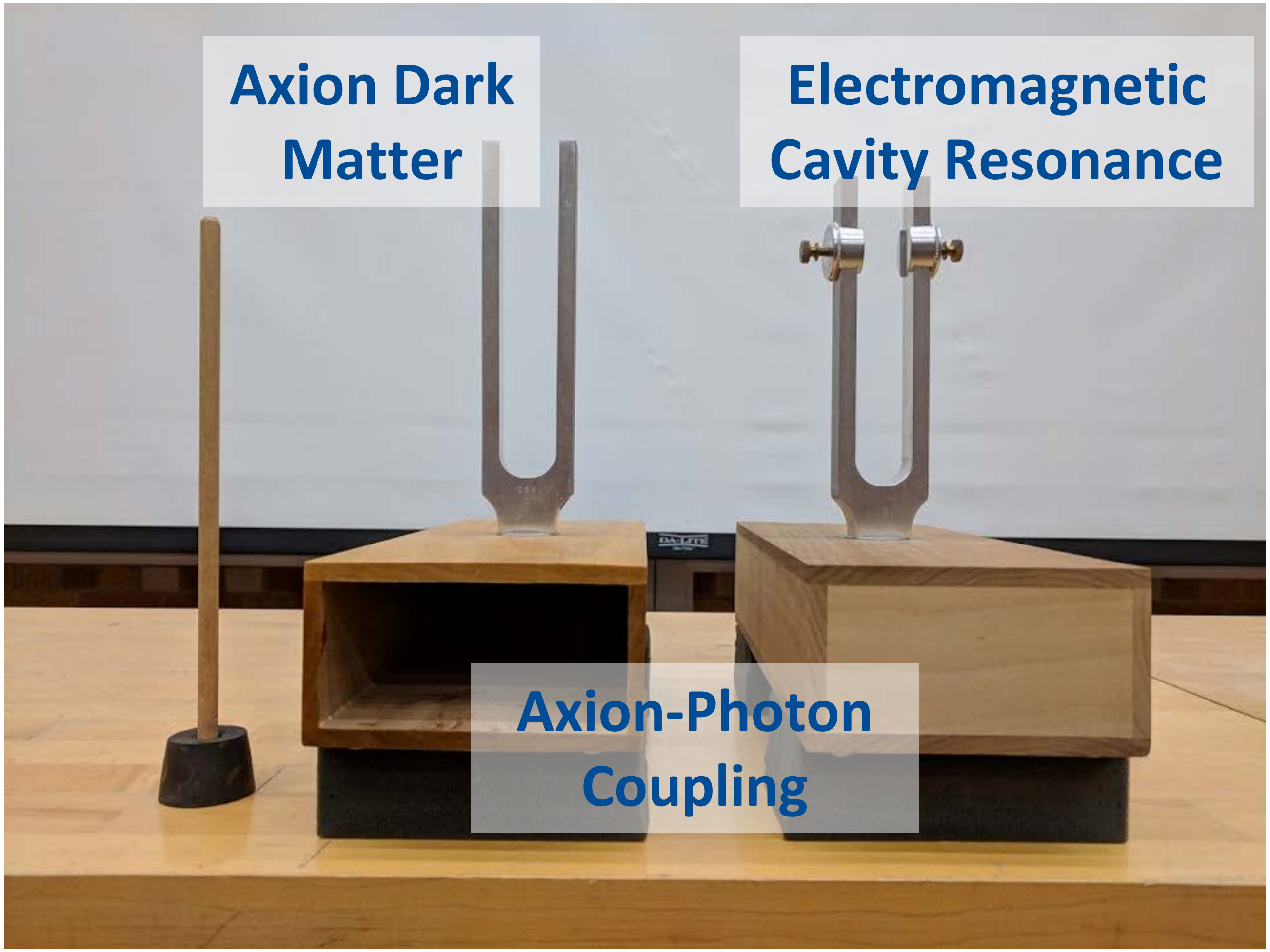
## The Axion Haloscope



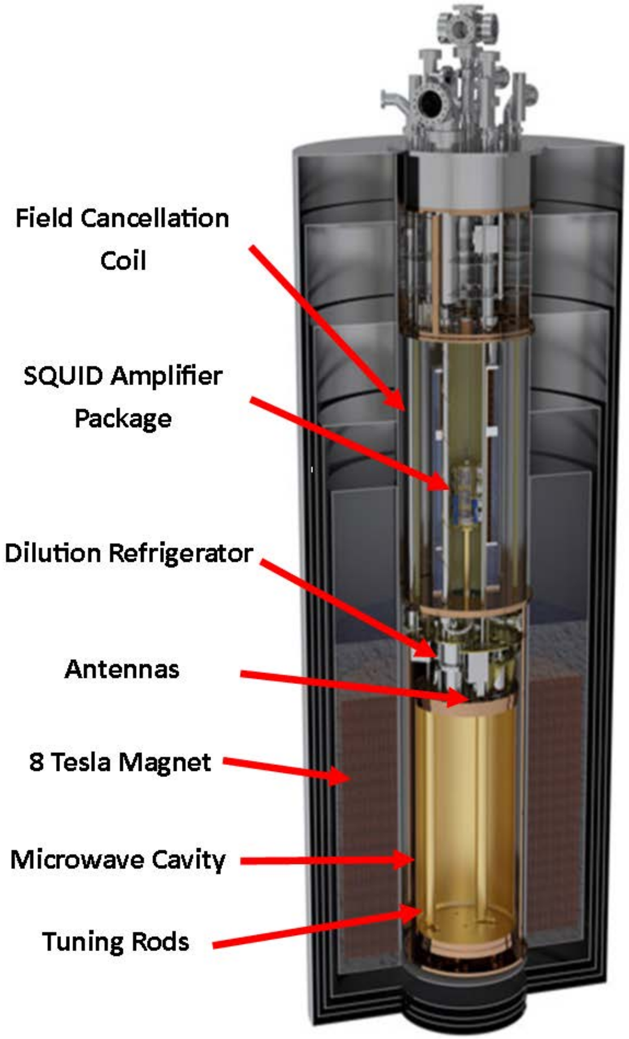
# Classical Analog to the Axion Haloscope

ADMX
AXION DARK MATTER EXPERIMENT

# Classical Analog to the Axion Haloscope



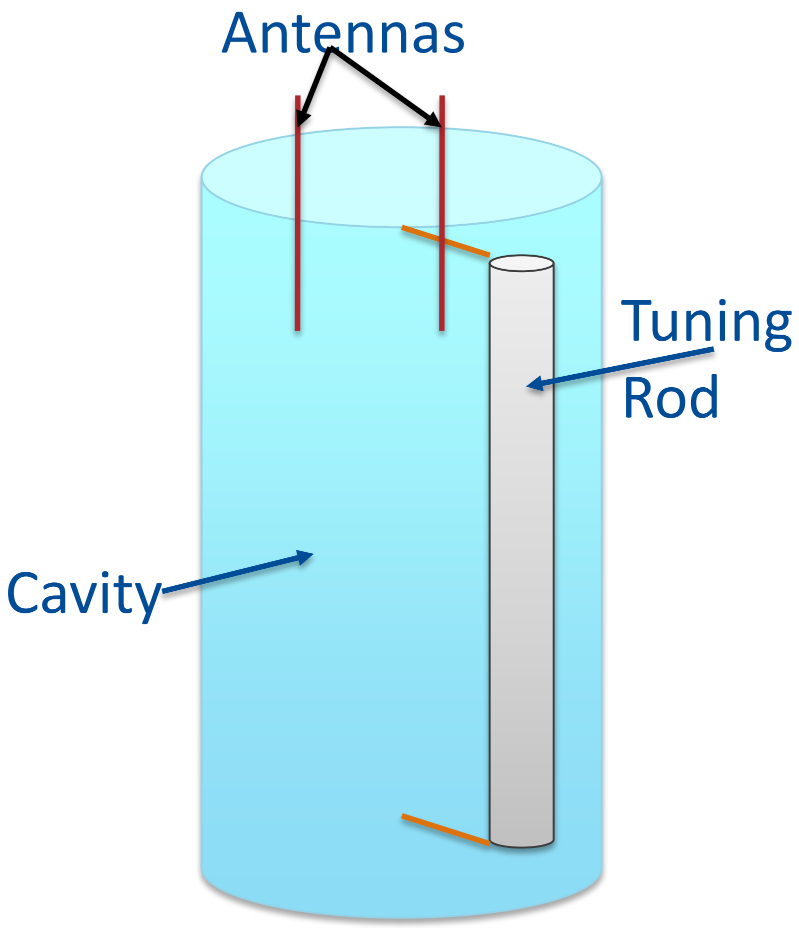
# General Design

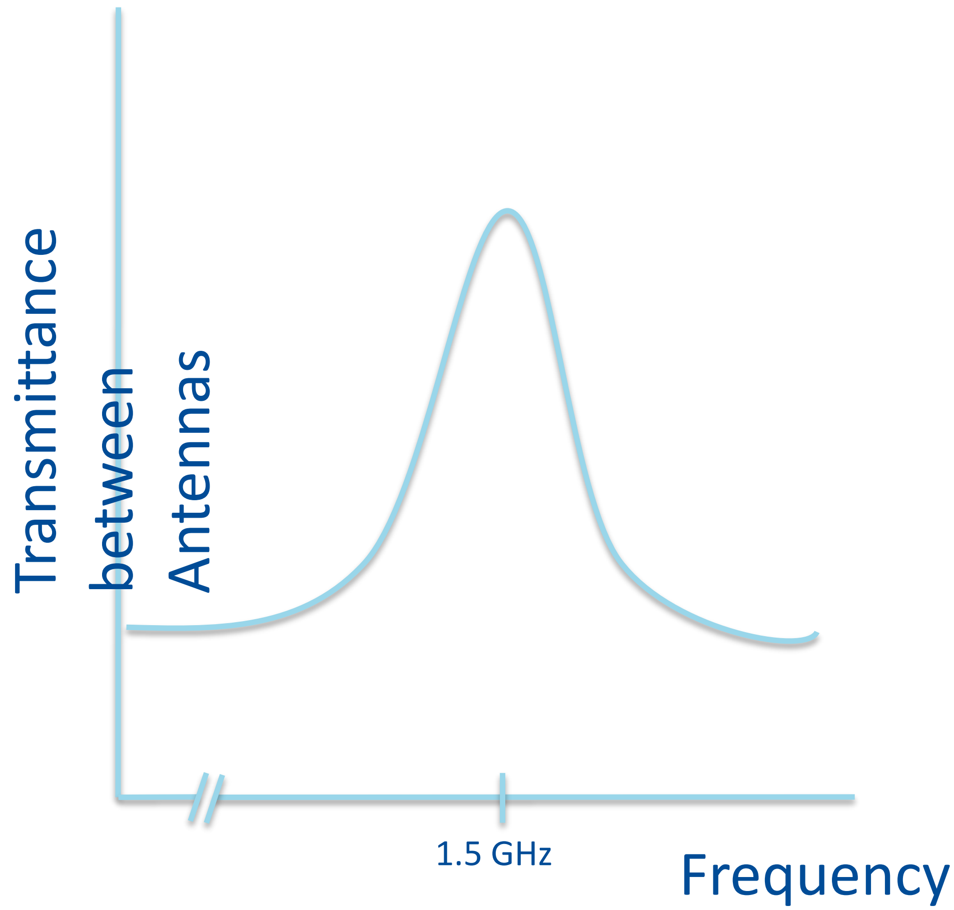



$$\frac{df}{dt} \approx 1.68 \text{ GHz/year} \left(\frac{g_\gamma}{0.36}\right)^4 \left(\frac{f}{1 \text{ GHz}}\right)^2 \left(\frac{\rho_0}{0.45 \text{ GeV/cc}}\right)^2 \cdot \left(\frac{5}{SNR}\right)^2 \left(\frac{B_0}{8 \text{ T}}\right)^4 \left(\frac{V}{100 \text{l}}\right)^2 \left(\frac{Q_L}{10^5}\right) \left(\frac{C_{010}}{0.5}\right)^2 \left(\frac{0.2 \ K}{T_{sys}}\right)^2$$

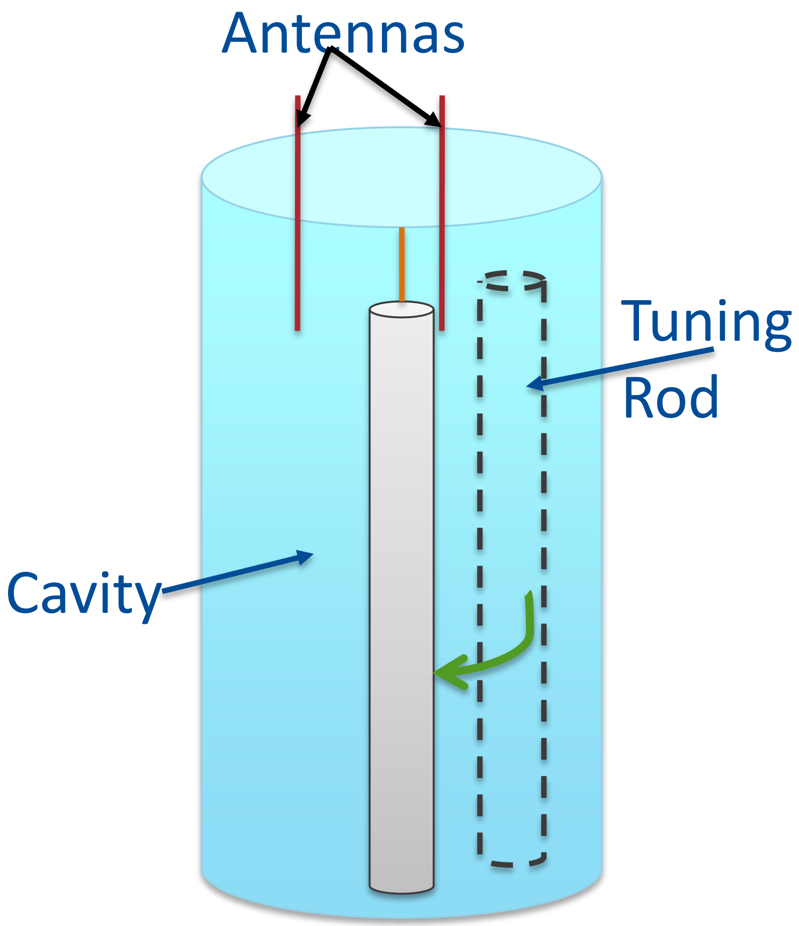
- $C_{lmn}$-Cavity Mode form factor
  - 010 is best for axion searches
- Reducing $T_{sys}$
  - $T_{sys} = T_{phys} + T_{amp}$
  - Quantum Amplifier
  - Dilution Refrigerator

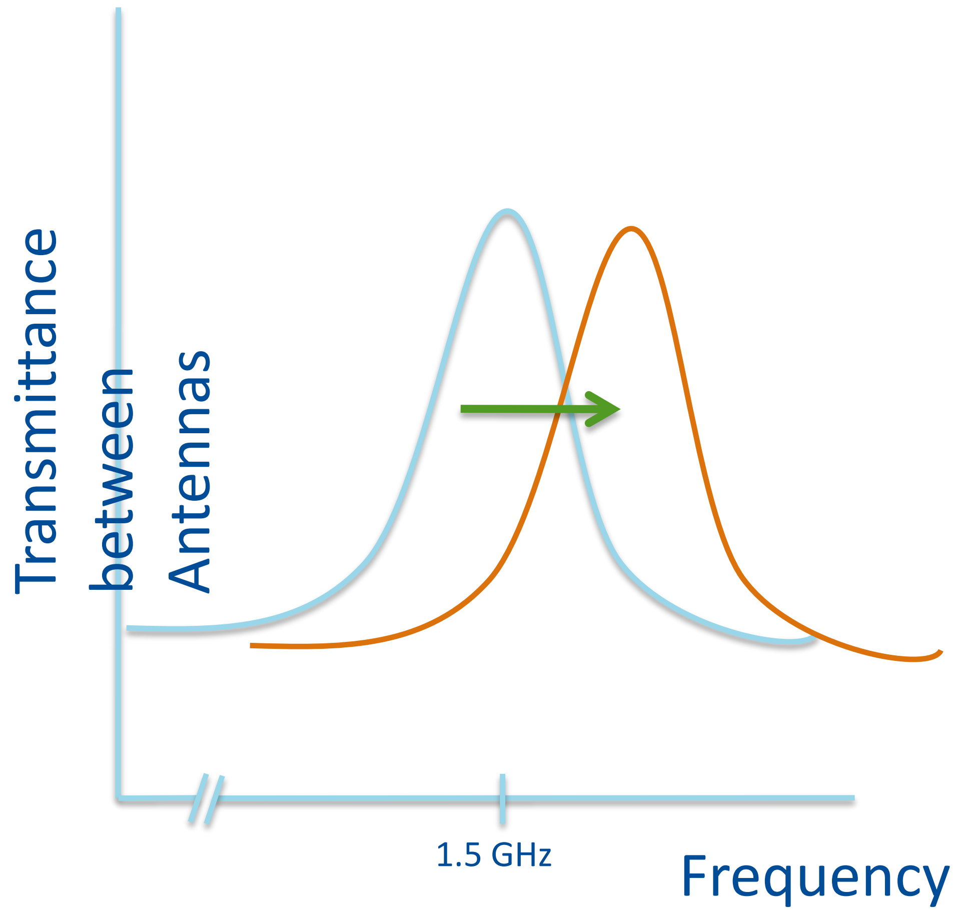
# Tunable Cavity



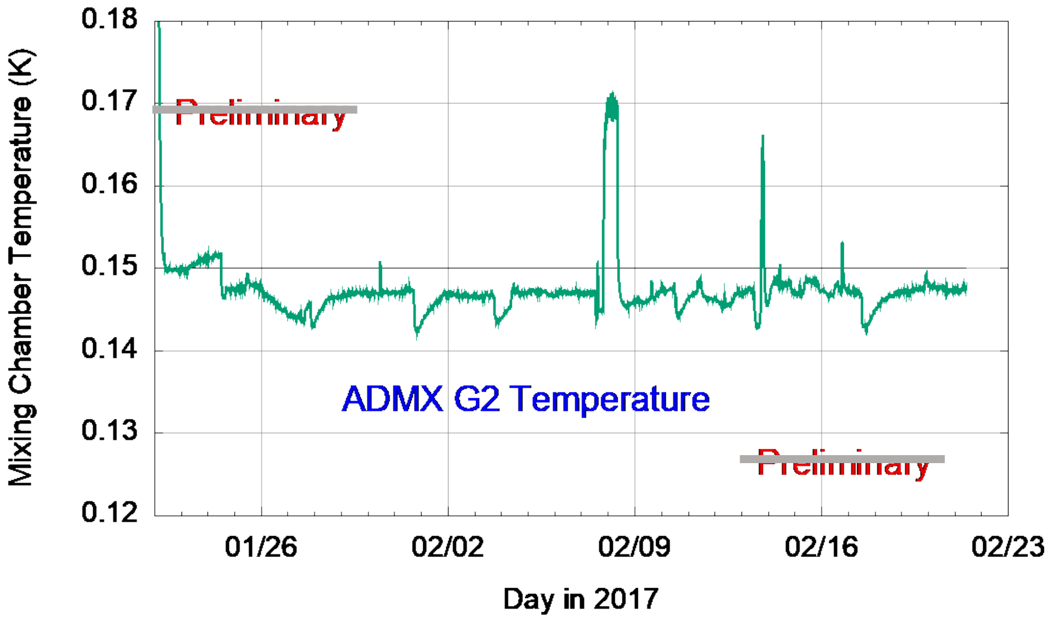



# Tunable Cavity



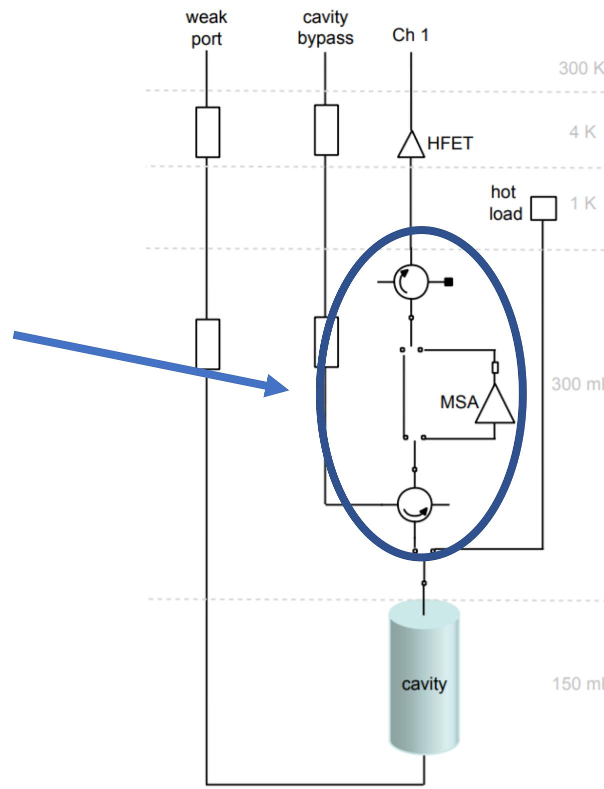



# Dilution Refrigerator

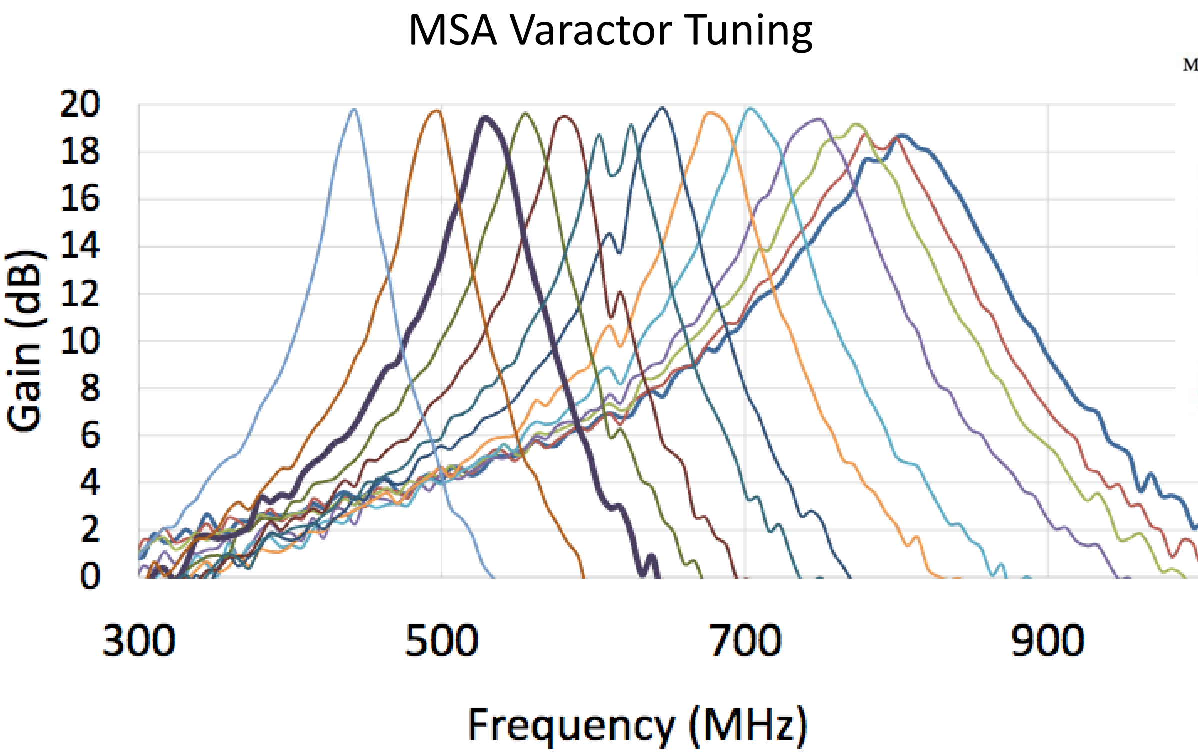


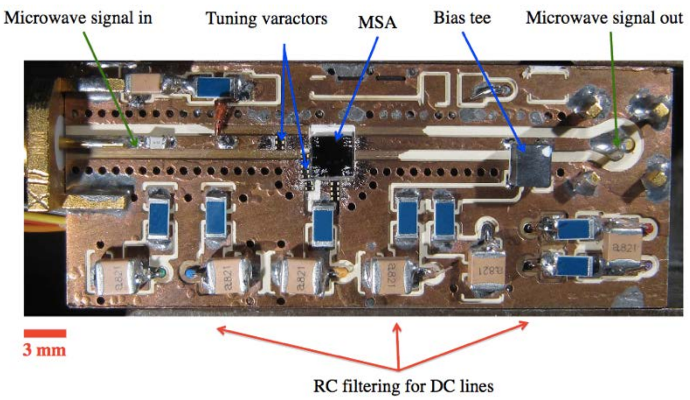
# ADMX Receiver-Cold Electronics


Microstrip SQUID Amplifiers



# MSA Tunability



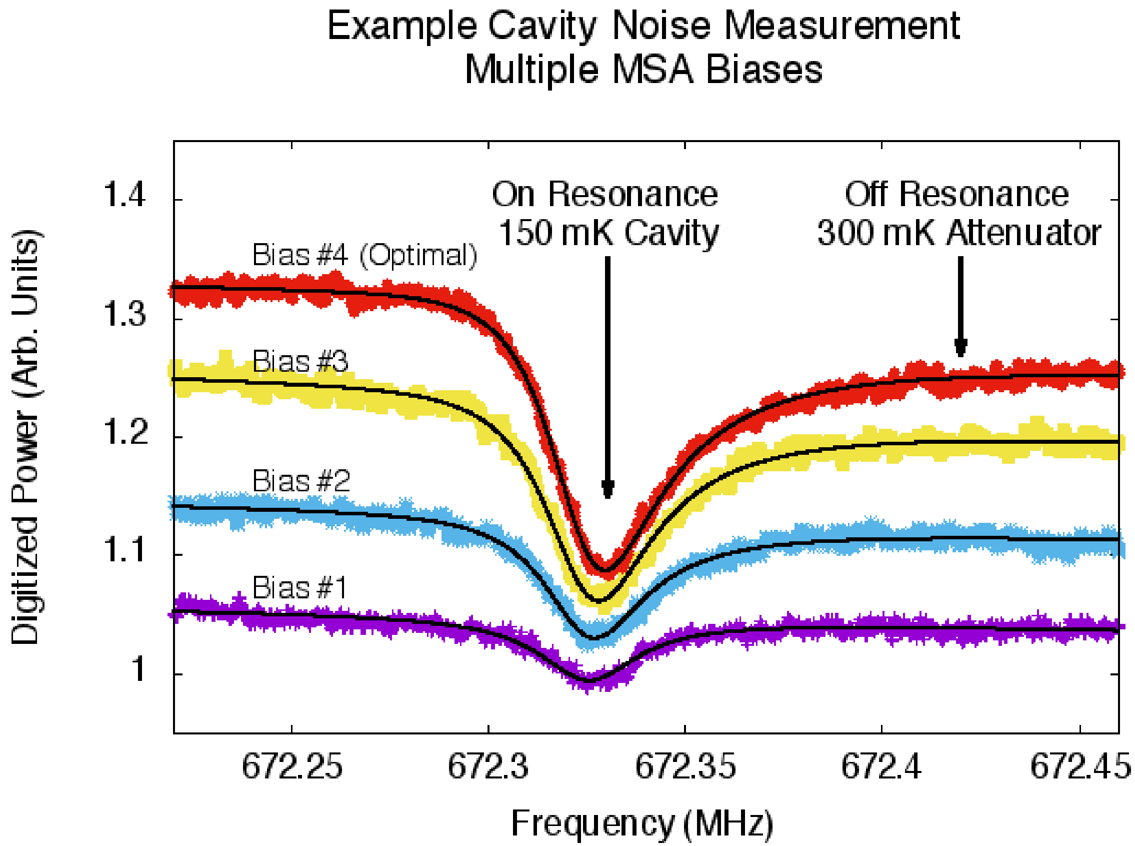



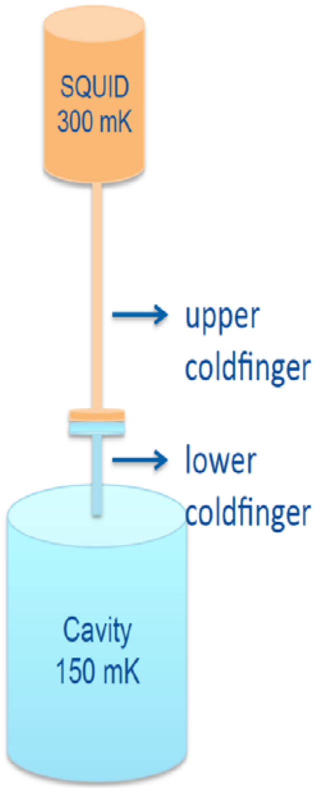

**ADMX Tunable MSA**

See: Sean O'Kelley (The Microstrip SQUID Amplifier in ADMX)

# MSA Operations

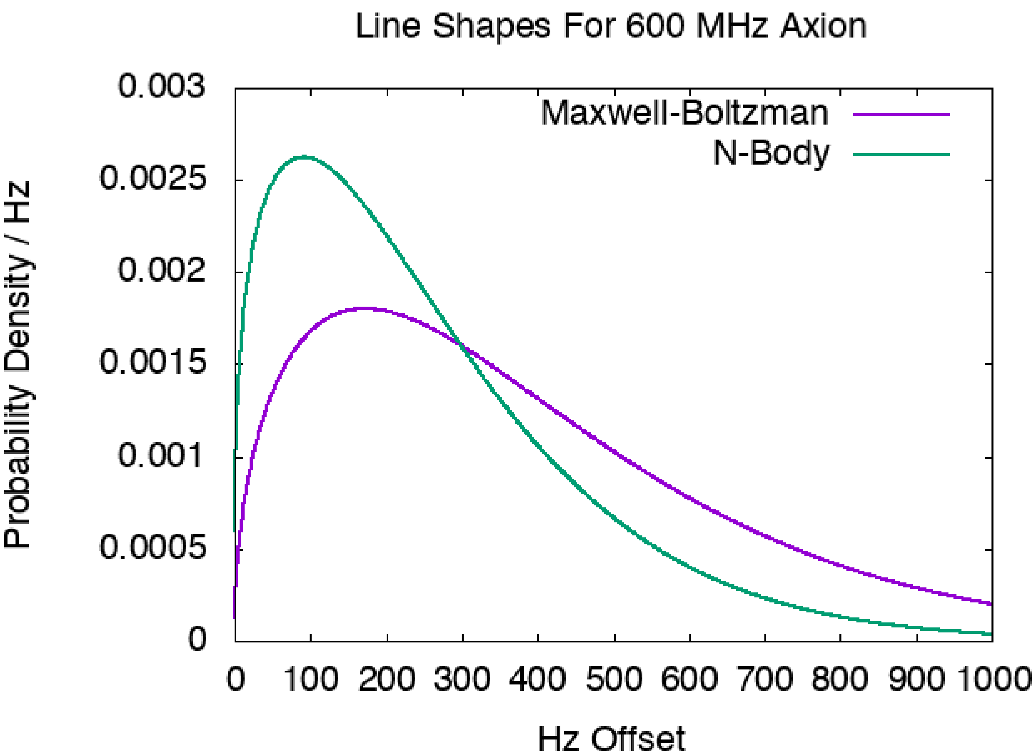
- Amplifier package at higher temperature than cavity due to thermal short.
- Causes distinctive "dip" in noise power at cavity resonance.
- Typical system noise temperature was ~500 mK.



# Expected Axion Lineshape

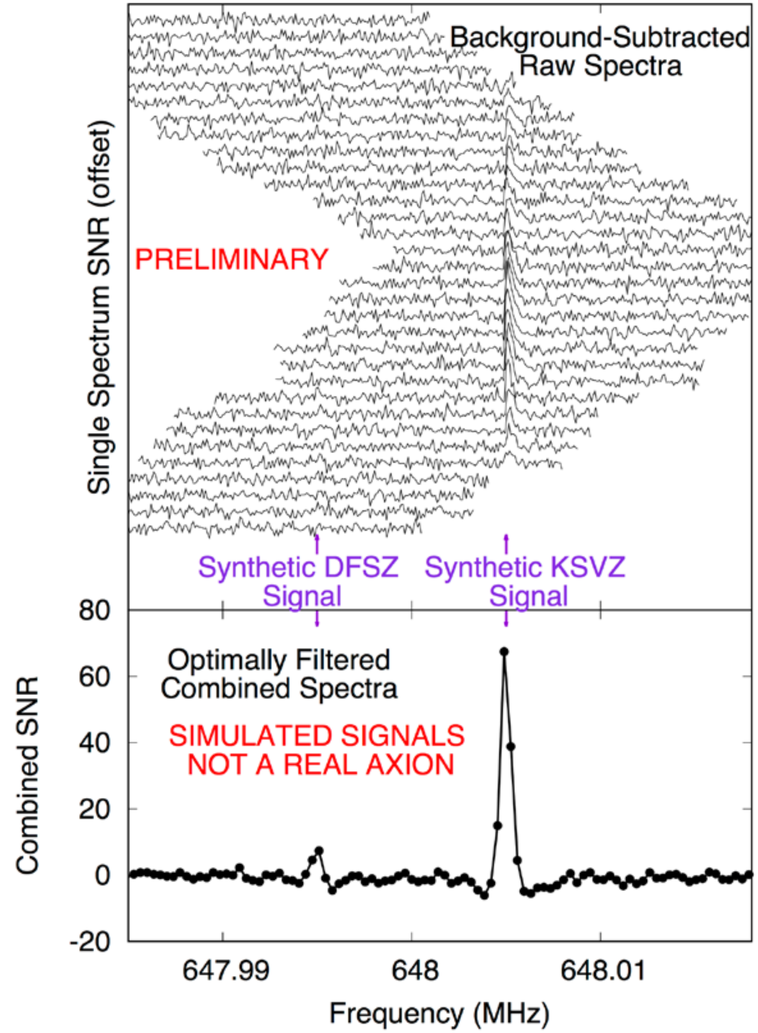
- Previous searches have modeled the axion lineshape as a isothermal sphere
- N-body simulations suggest a narrower lineshape
- Our analysis searches for both



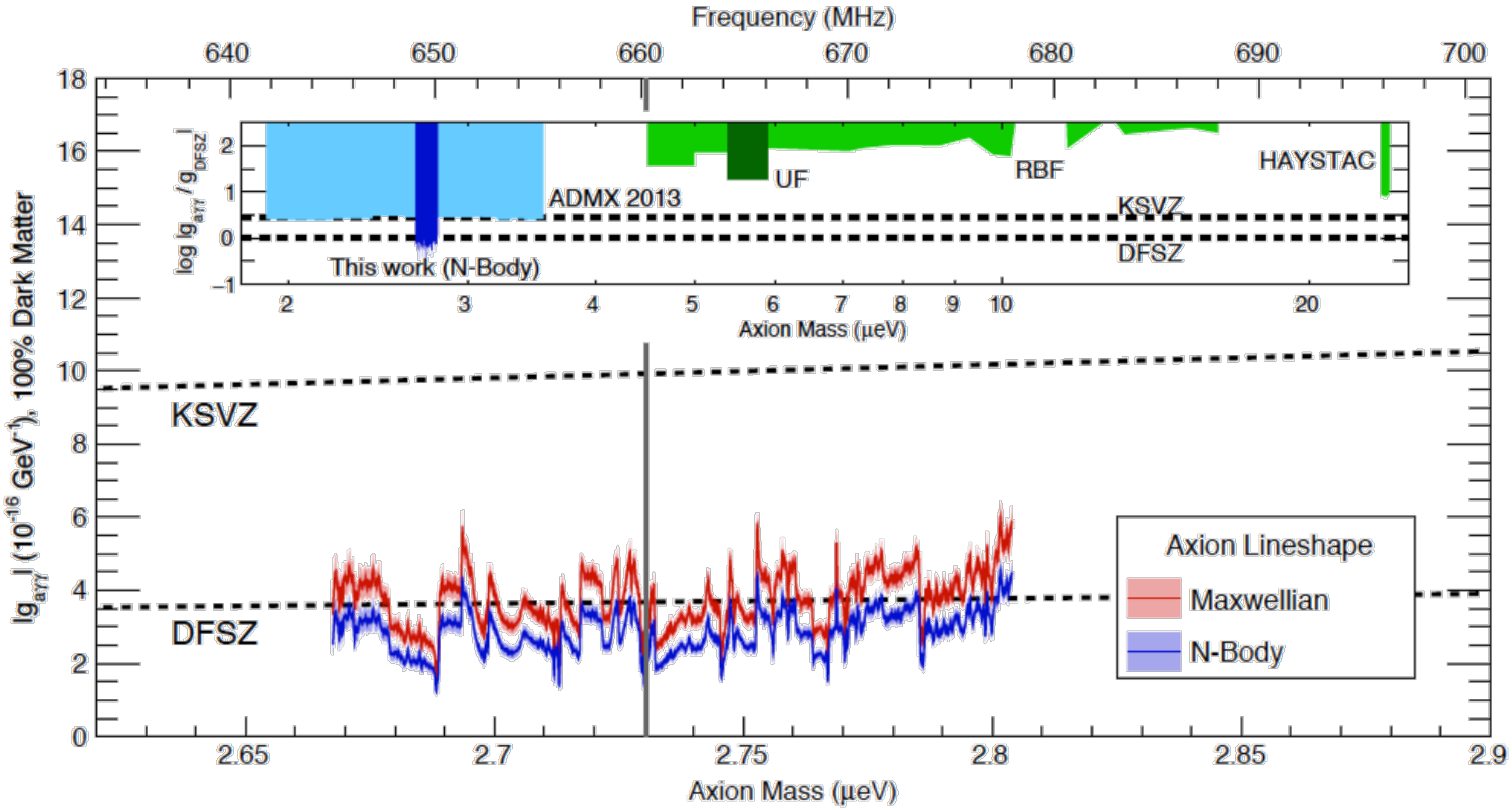

Adapted from: Lentz et al. Ap.J. 845 (2017)

# Simulated Signals in Real Data

- Injected synthetic software signals to evaluate analysis
- KSVZ and DFSZ axion signals (N-body lineshape) are shown
- DFSZ axion signals should be visible in analysis



# ADMX Limits 2017




N. Du *et al.* (ADMX Collaboration), "Search for Invisible Axion Dark Matter with the Axion Dark Matter Experiment," [Phys. Rev. Lett. **120**, 151301 (2018)](https://doi.org/10.1103/PhysRevLett.120.151301).

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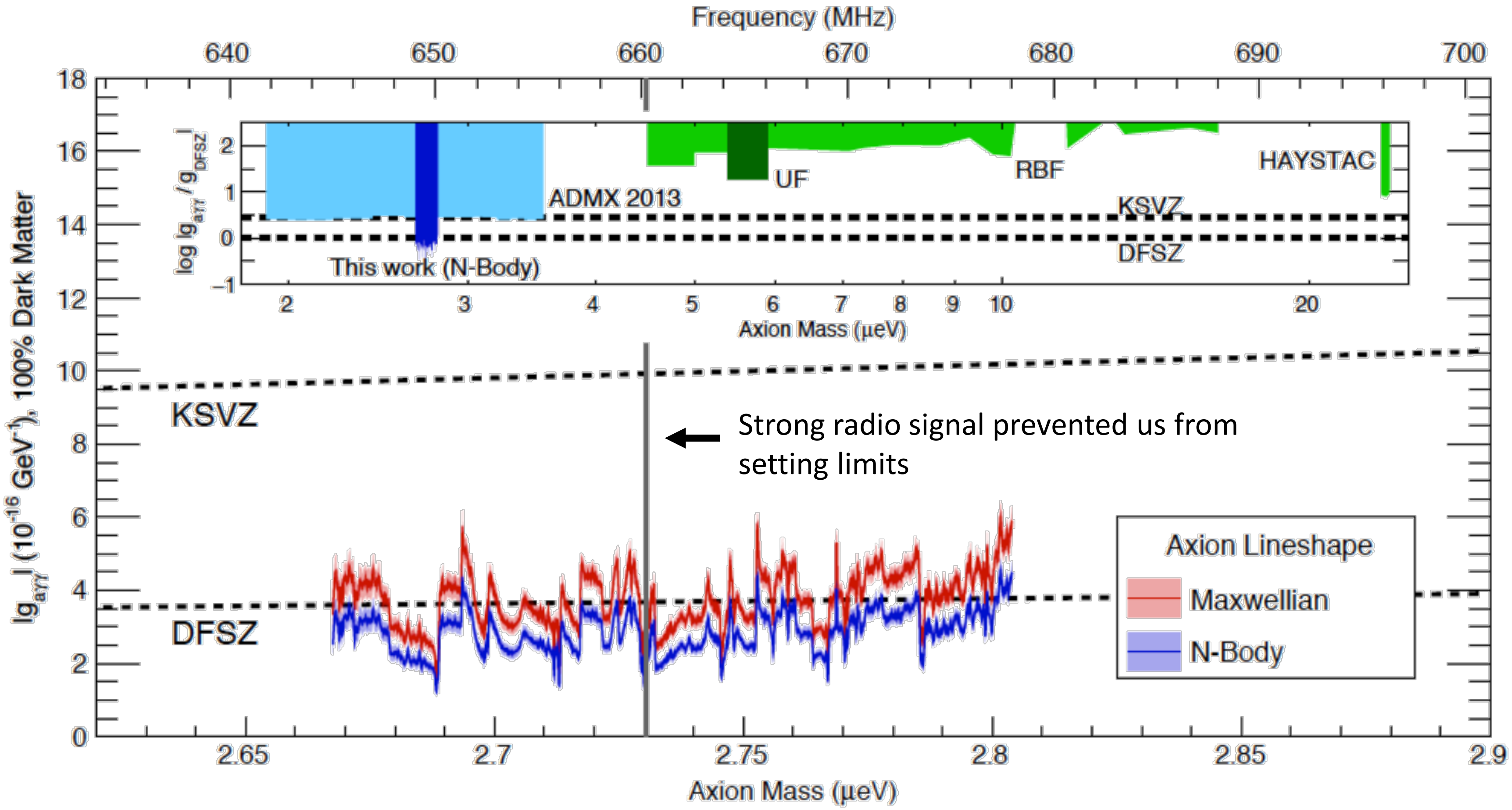
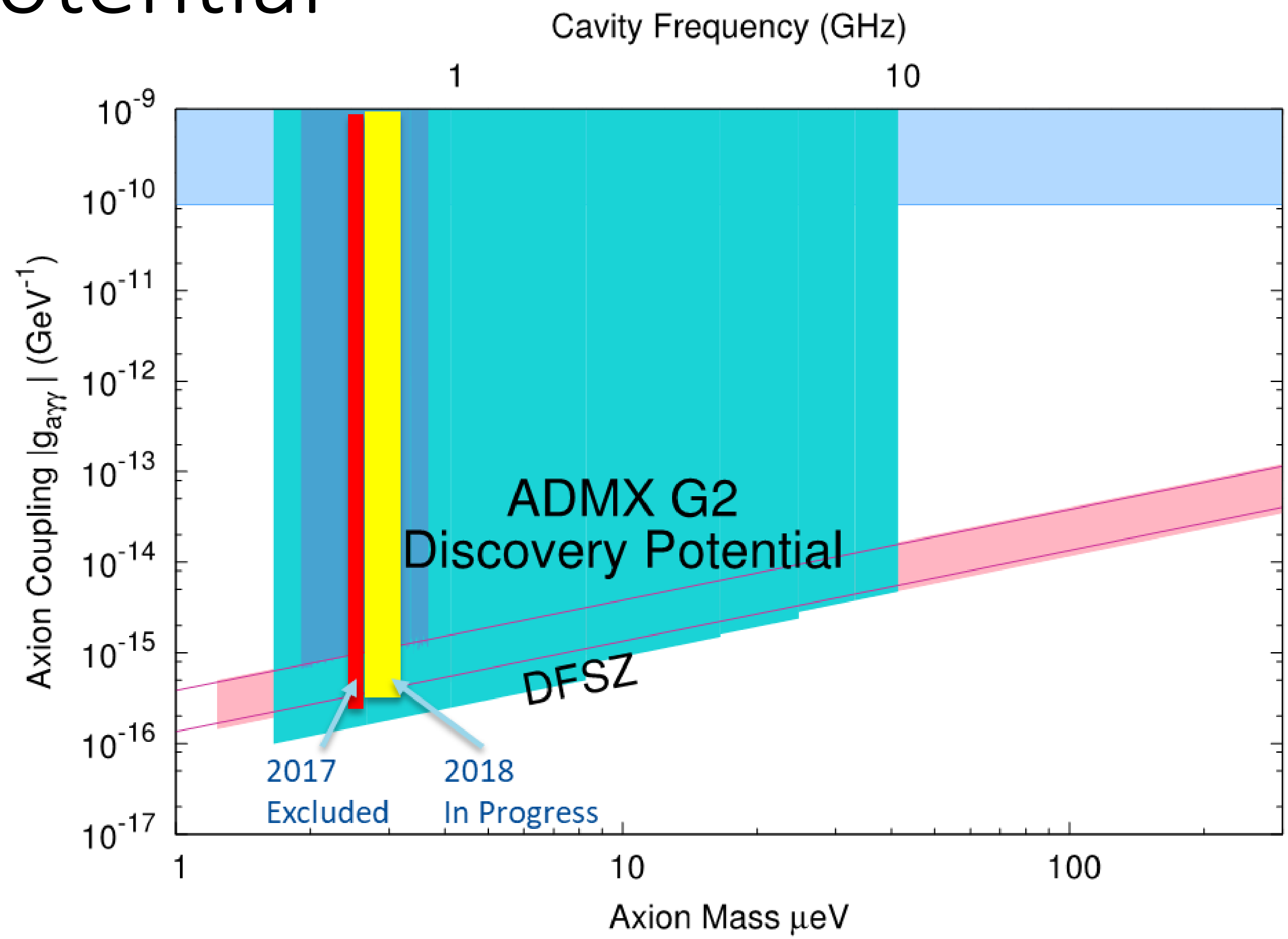
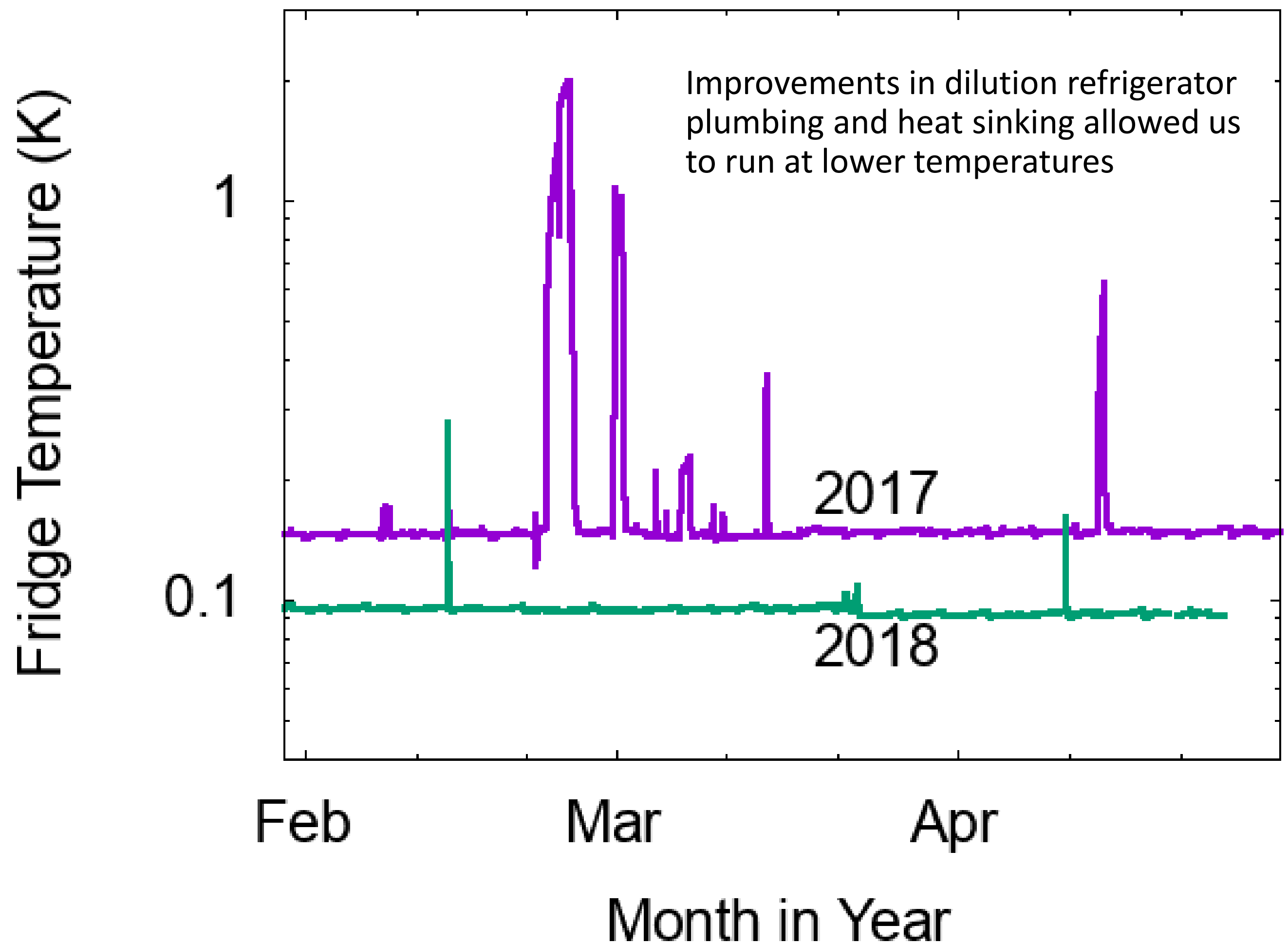



N. Du *et al.* (ADMX Collaboration), "Search for Invisible Axion Dark Matter with the Axion Dark Matter Experiment," Phys. Rev. Lett. **120**, 151301 (2018).

# ADMX G2 Discovery Potential



# 2018 Run: Cryogenics

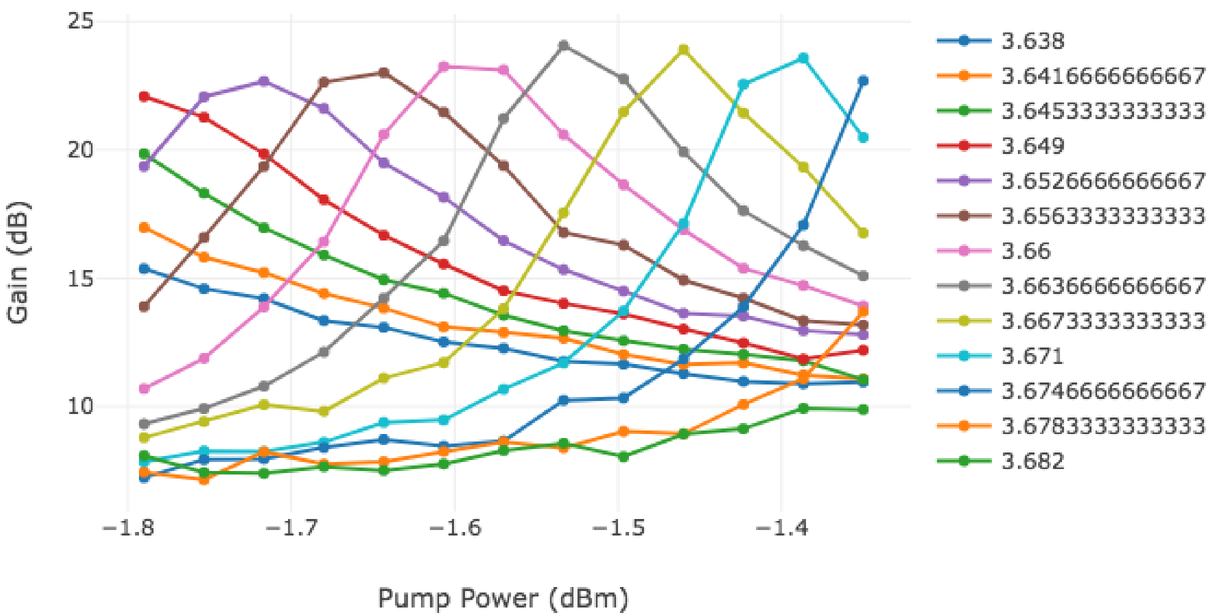


# 2018 Run: RF Electronics

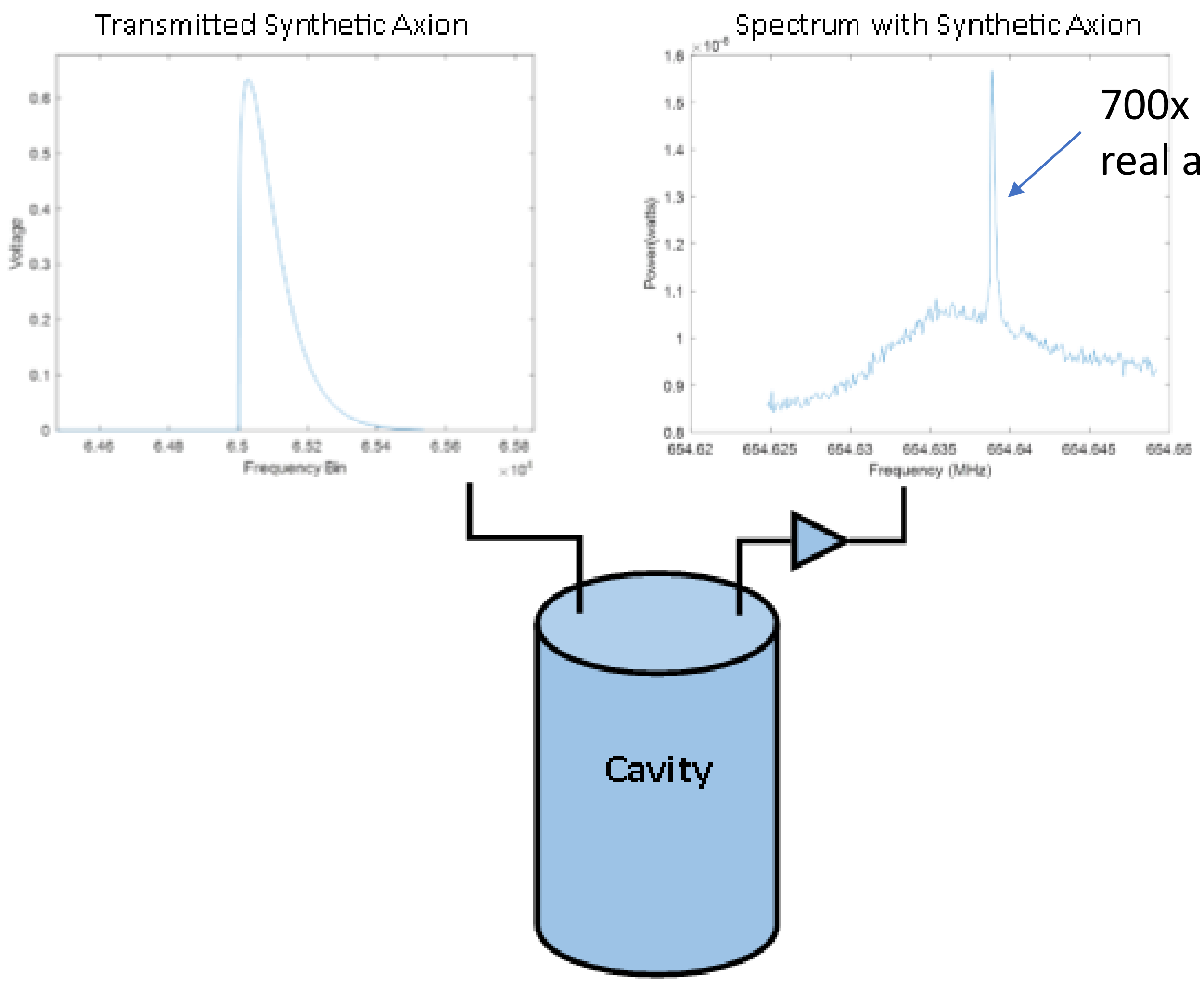
**ADMX Josephson Parametric Amplifier**

Yanjie Qiu, Siddiqi Group, UC Berkeley

Gain Tuning Curves of Operating ADMX JPA

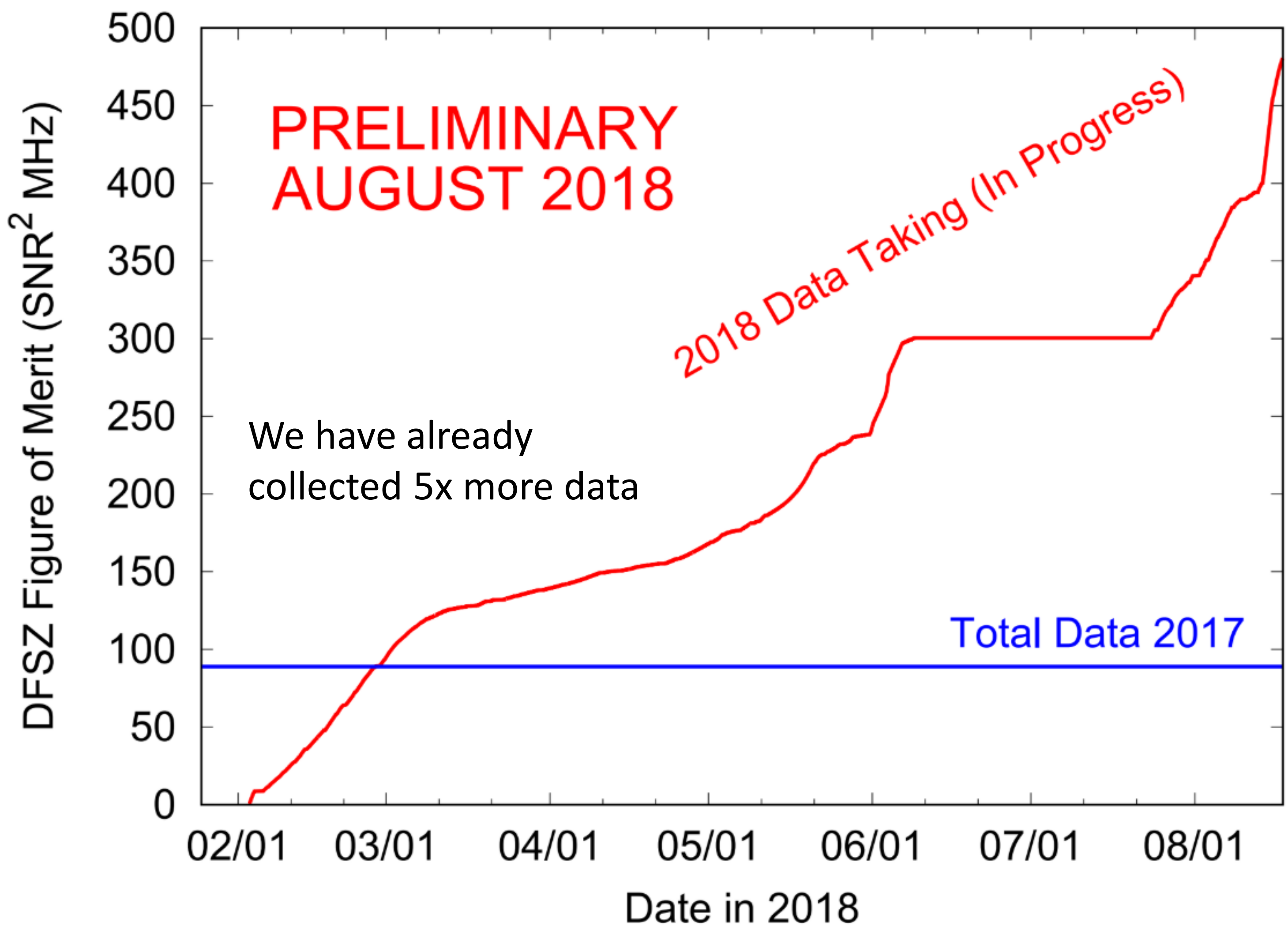


# Run 2018: Blind Injections

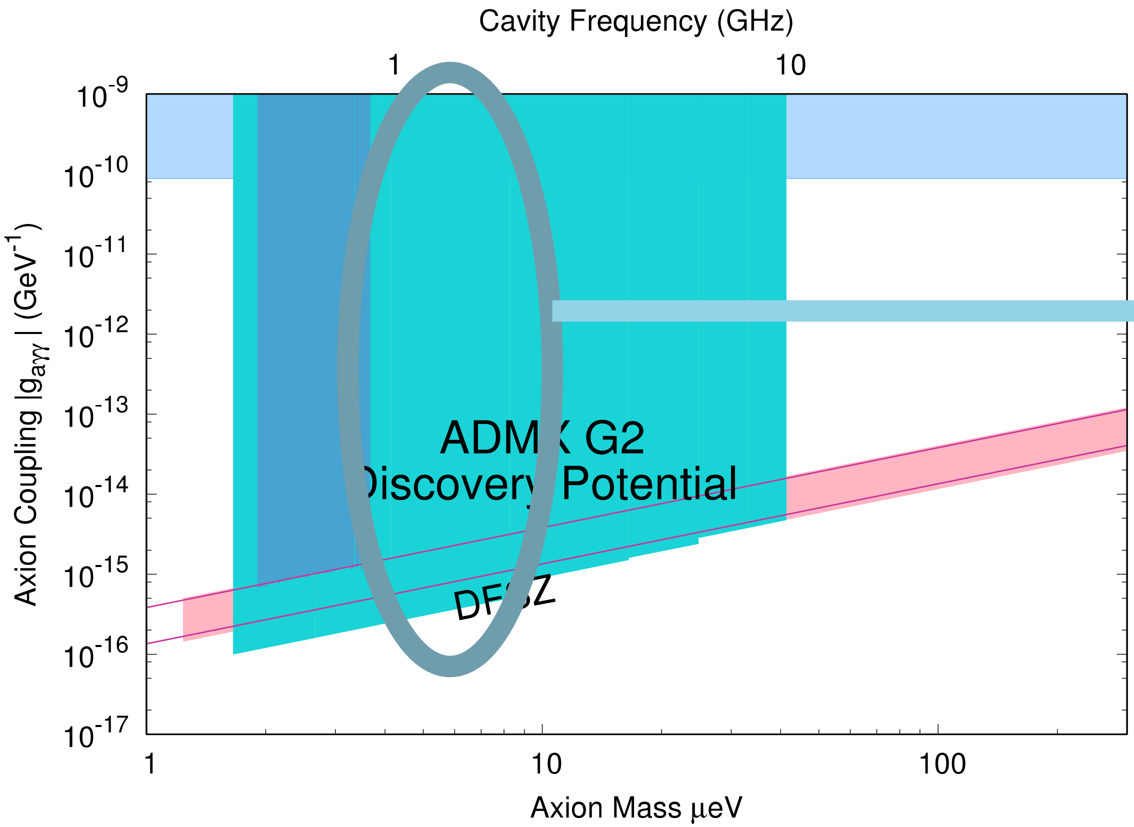


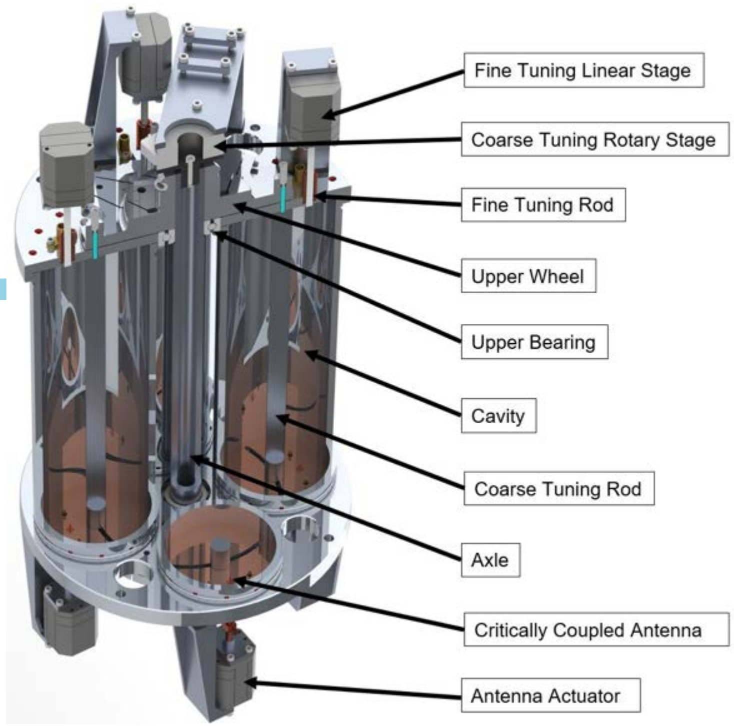

700x larger than real axion signal

# 2018 Run: Data



# Higher Frequency Searches

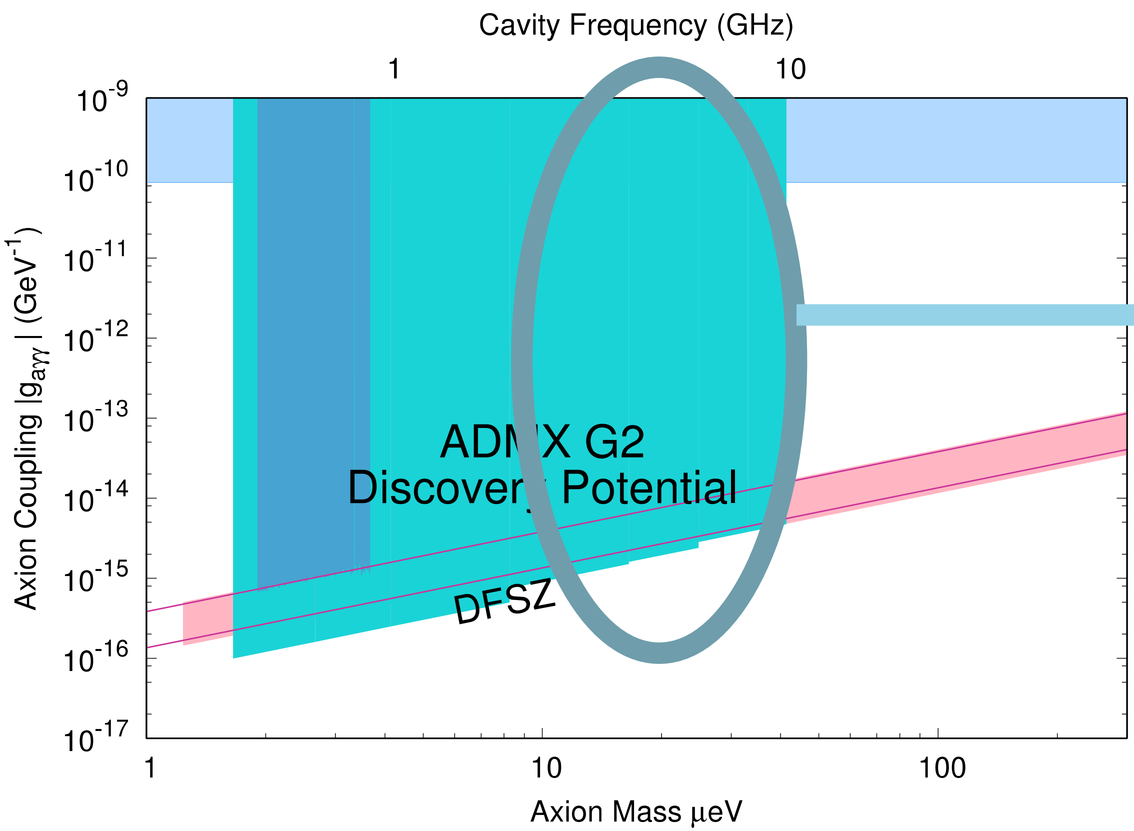



See: Joe Gleason (ADMX 2A Cavity Array Mechanical Design)

# Higher Frequency Searches

AXION DARK MATTER EXPERIMENT




See: Jihee Yang (Reaching the 5-9μeV Range with ADMX: Multi-Cavity Array)

# Conclusions

- ADMX has achieved sensitivity to DFSZ axions, a benchmark for QCD axion searches
- Improvements from our previous run have allowed us to operate with increased scan speeds
- ADMX is in a position to make a discovery at any time

# Acknowledgements


- The ADMX collaboration gratefully acknowledges support from the US Dept. of Energy, High Energy Physics DE-SC0011665 & DE-SC0010280 & DE--AC52-07NA27344. Also support from the Heising-Simons Foundation.
- Thank you ADMX collaborators at
  - UW, UFL, LLNL, FNAL, UCB, PNNL, LANL, NRAO, WU, Sheffield

# Questions?

# You might have an axion signal if…

- can't be seen in the room outside of the magnetic field
- persists all the time
- follows the lorentzian lineshape of the cavity
- is suppressed in non TM010 modes
- scales with the $B^2$ of the magnet
- has a tiny daily and annual frequency modulation