Pacific Northwest NATIONAL LABORATORY

ADMX AXION DARK MATTER EXPERIMENT

Current Status and Future Plans of the Axion Dark Matter eXperiment

August 31, 2023
XVIII TAUP
Vienna, Austria

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For the ADMX Collaboration

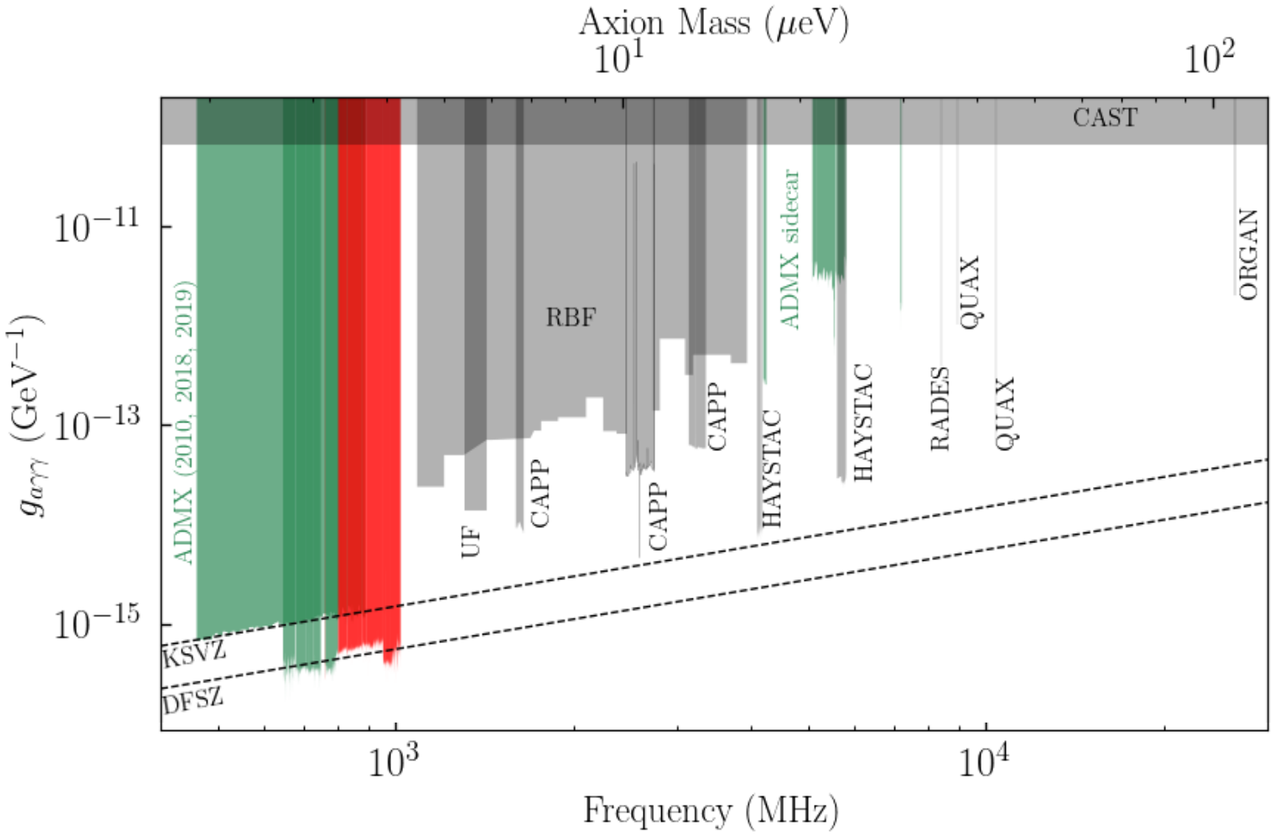
U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

QCD Axions as Dark Matter

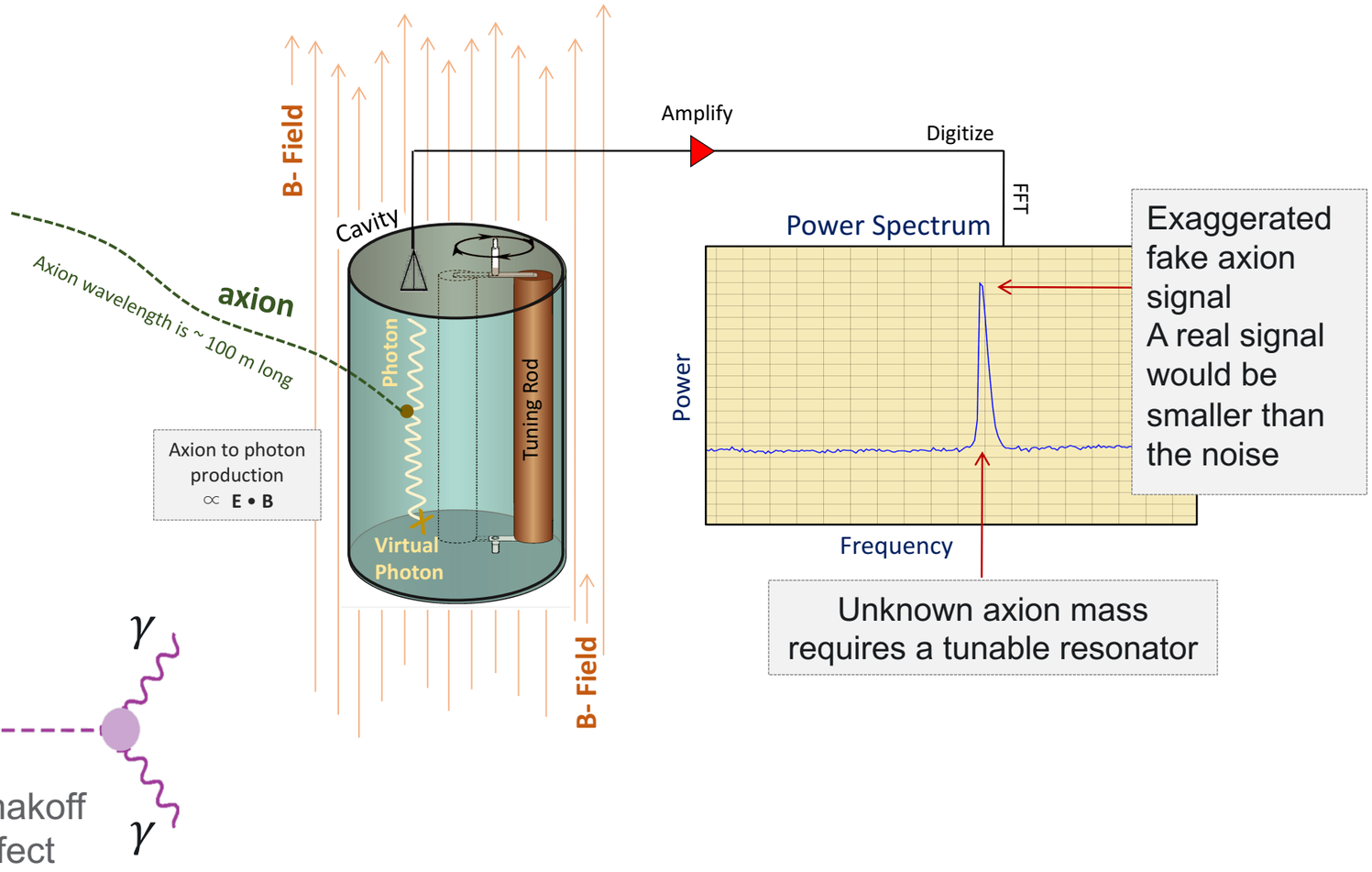
- We don't know what the dark matter is
- But we know it has certain properties:
  - Cold
  - Feebly interacting
  - Stable
  - Non-baryonic
- Axions with certain properties could make up dark matter
  - They arise from the Peccei-Quinn mechanism
  - Pseudo-scalar boson
  - Small mass
  - Long wavelength

Axion parameter space circa 2021

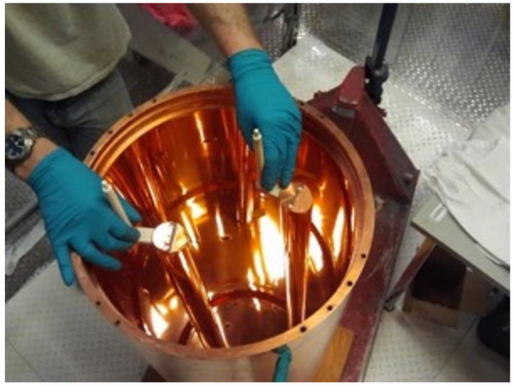


Red data: C. Bartram, *et al.*, Phys. Rev. Lett. 127, 261803 (2021)

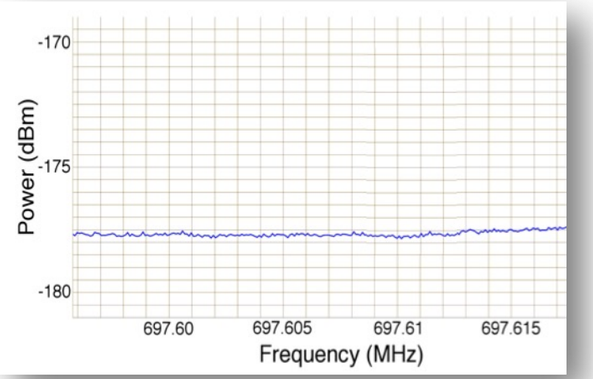
Searching for Axions with a Haloscope



Tunable Microwave Cavity



Typical Data



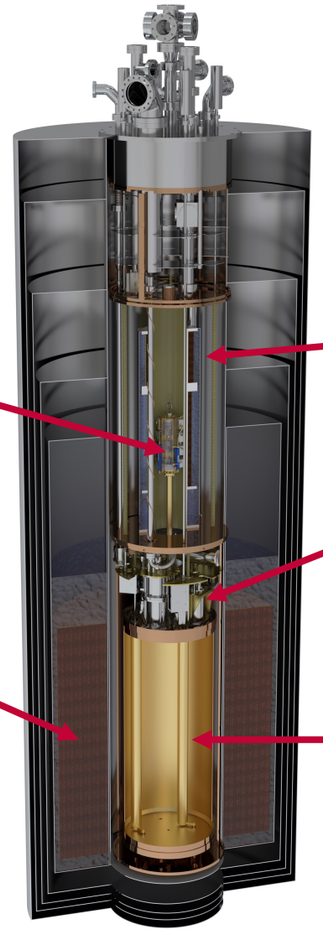
The Axion Dark Matter eXperiment

ADMX Site: Center for Experimental Nuclear Physics and Astrophysics
University of Washington, Seattle, WA

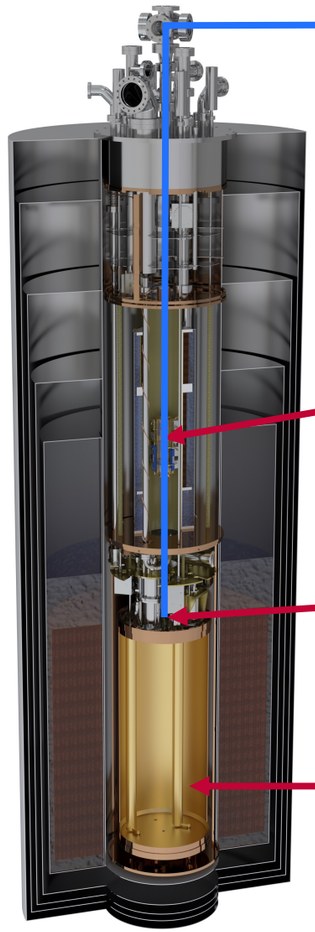
ADMX insert extraction ca. 2015

ADMX Experiment Site – Image: Mark Stone, UW

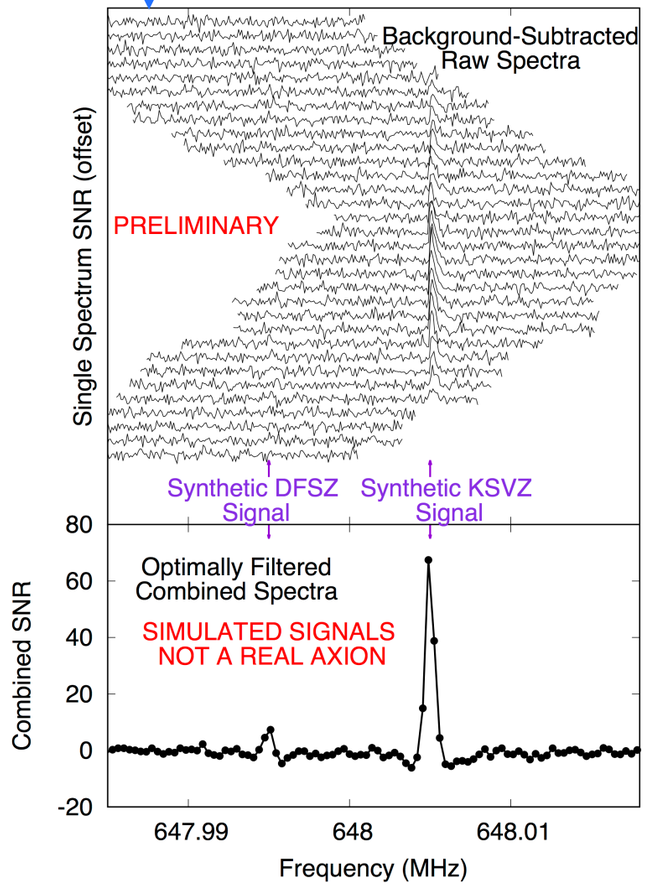
Inside ADMX


JPA and cryogenic RF components
Primary magnet: 7.5 T
Field cancelation magnet
Dilution refrigerator
Microwave cavity with tuning rods

Listening for Axions with ADMX



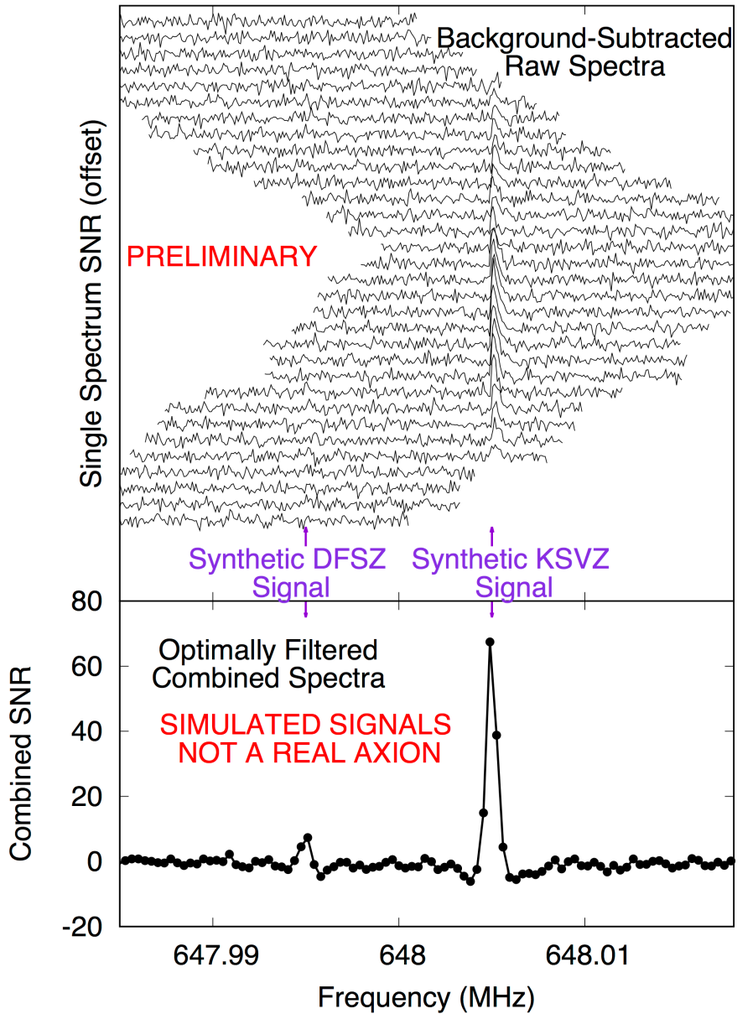
4. Signal is read out with room-temperature RF signal processing
3. Signal is amplified by the JPA
2. Antenna reads the signal from the TM010 mode
1. Tuning rods adjust resonant frequency



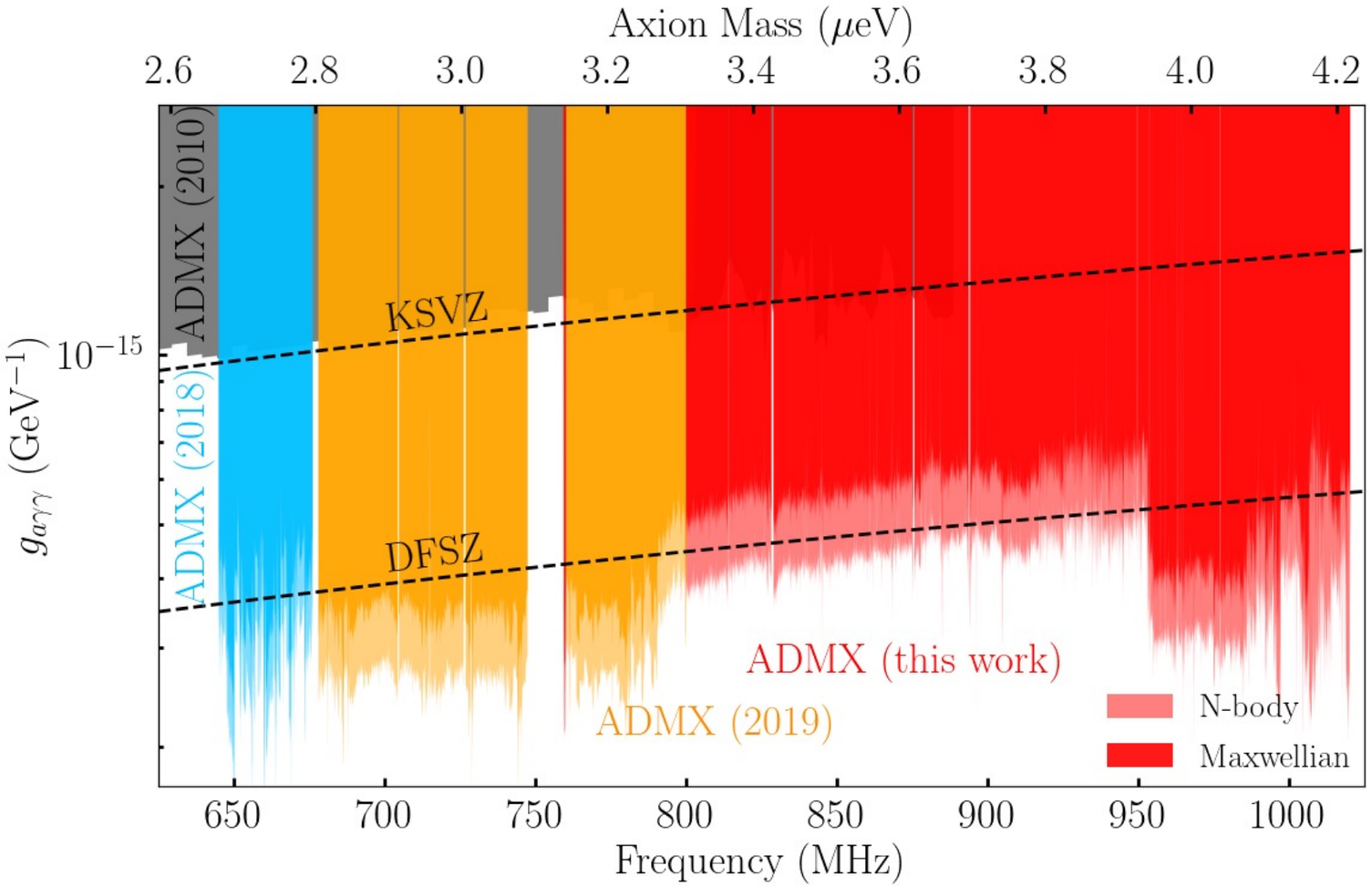
How to be Sure we Found an Axion

A persistent signal must:

- Not be from the synthetic signal source
- Not be ambient RF interference: measure with an external receiver
- Appear in every spectrum at the same frequency
- Be enhanced on resonance
- Be suppressed in modes that do not couple to the axion
- Scale as B^2

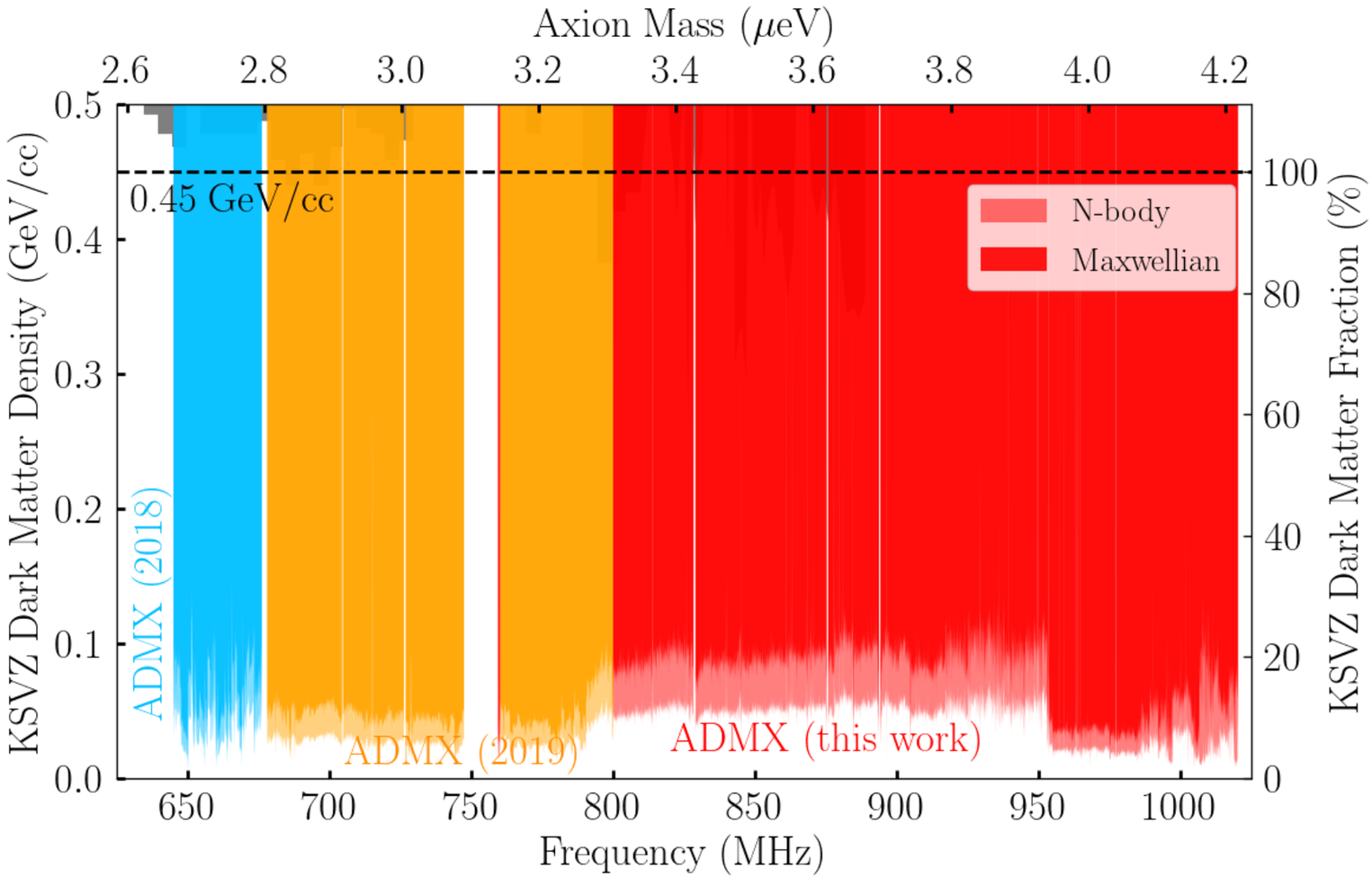


Axion Limits through 2021



C. Bartram, *et al.*, Phys. Rev. Lett. 127, 261803 (2021)

Alternate View: KSVZ Dark Matter Density



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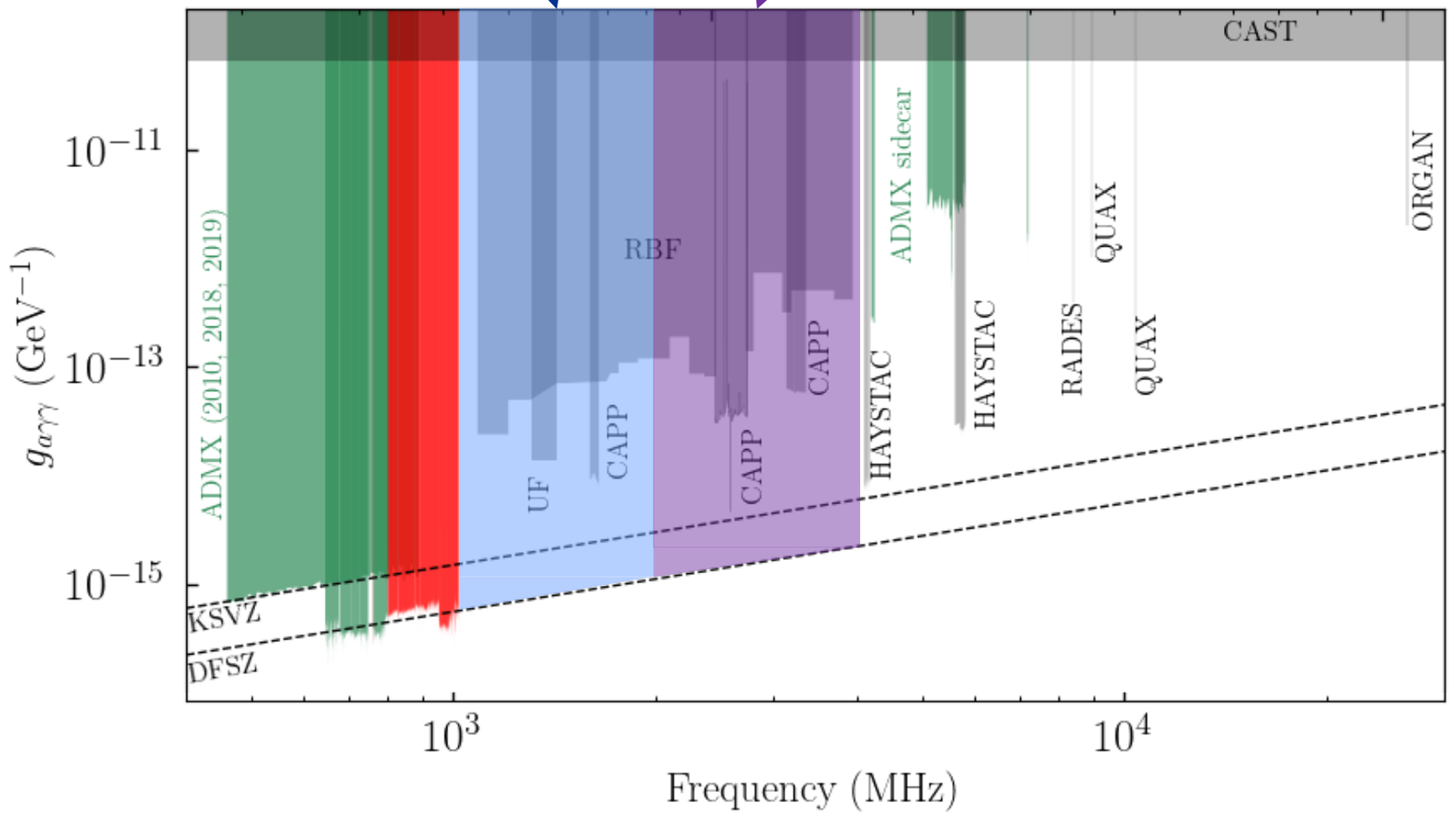
Future Phases of ADMX

Completion of ADMX-G2

New program: ADMX-EFR



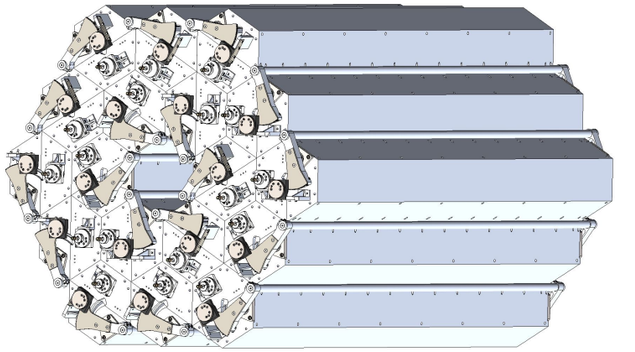
Pursuing Higher Frequencies

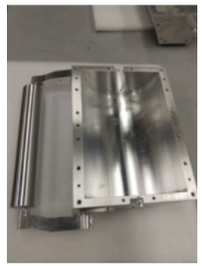
Scan rate for a cavity haloscope $\frac{df}{dt} \propto f^2 \mathrm{SNR}^{-2} Q_L V^2 B^4$

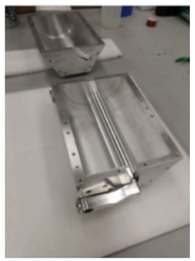
- As the resonant frequency of the cavity goes up
  - Volume decreases: $V \propto \frac{1}{f^3}$
  - Quality factor decreases: $Q_L \propto \frac{1}{f^{2/3}}$
  - Noise power increases: $T \propto f$
- How do we maintain a reasonable scan speed?

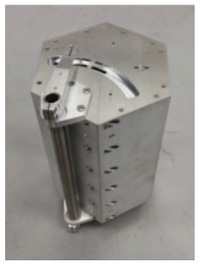
Overcoming Challenges for Higher Frequencies

- Increase the magnetic field: **new main magnet**
- Increase volume: **multiple cavities**
- Increase the quality factor: **superconducting films**
- Minimize system noise: **squeezed states**



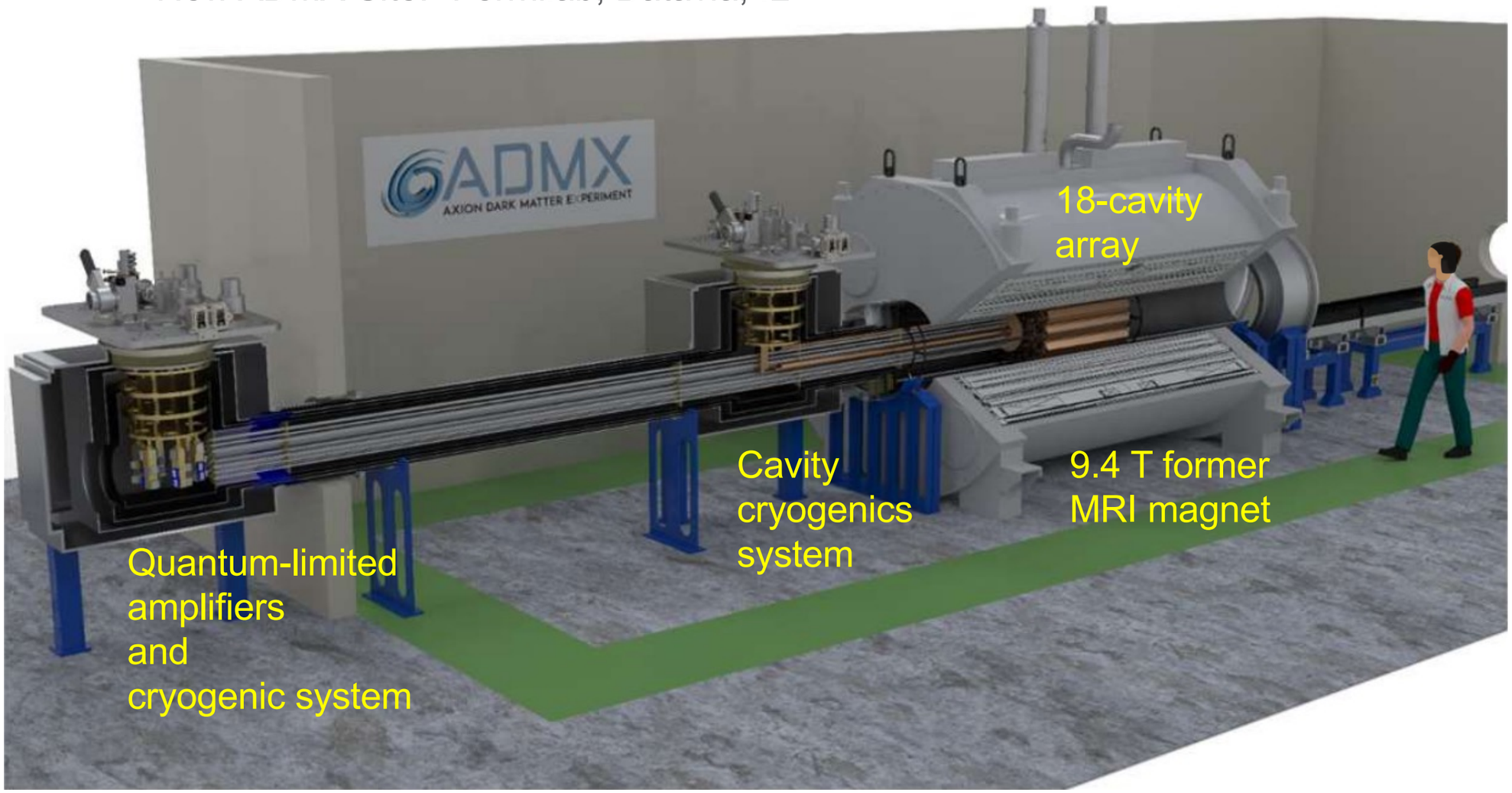






ADMX Extended Frequency Range: 2-4 GHz

New ADMX Site: Fermilab, Batavia, IL



Summary

- ADMX is taking data at DFSZ sensitivity
- Future iterations of ADMX will move up in frequency
- Multiple avenues of R&D work make the search for higher-mass axions promising

ADMX Collaboration

This work was supported by the U.S. Department of Energy through Grants No DE-SC0009800, No. DE-SC0009723, No. DE-SC0010296, No. DE-SC0010280, No. DE-SC0011665, No. DEFG02-97ER41029, No. DE-FG02-96ER40956, No. DEAC52- 07NA27344, No. DE-C03-76SF00098 and No. DE-SC0017987. Fermilab is a U.S. Department of Energy, Office of Science, HEP User Facility. Fermilab is managed by Fermi Research Alliance, LLC (FRA), acting under Contract No. DE-AC02-07CH11359. Pacific Northwest National Laboratory is a multi-program national laboratory operated for the U.S. DOE by Battelle Memorial Institute under Contract No. DE-AC05-76RL01830. Additional support was provided by the Heising-Simons Foundation and by the Lawrence Livermore National Laboratory LDRD office.