ADMX-VERA: A large volume haloscope for higher axion frequencies

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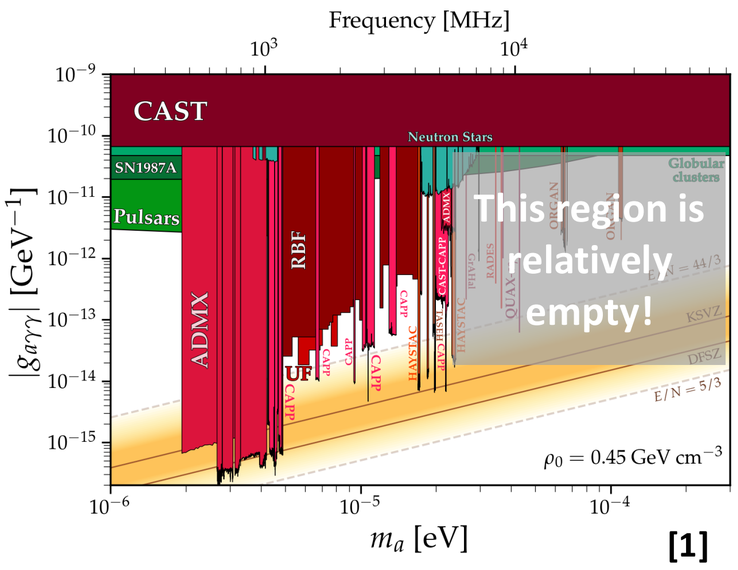
Haloscopes for higher frequencies

$$\frac{d\nu}{dt} \propto B_0^4 V^2 C^2 Q_L T_{\text{sys}}^{-2} \left(\frac{\beta}{1+\beta}\right)^2$$



[1]

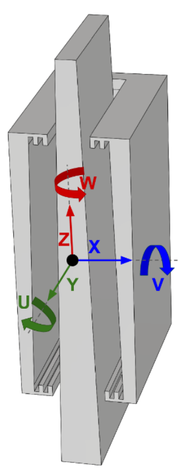
The volume of cylindrical cavities at high frequencies becomes smaller, making QCD-axion-sensitive high-frequency axion searches difficult

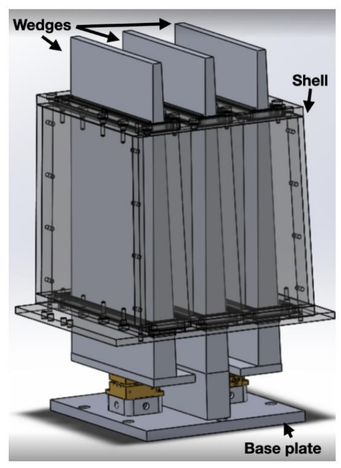
Resonant frequency

$$\nu = \frac{2.3\ [\text{GHz}]}{d\ [\text{mm}]/100}$$

$V \propto \nu^{-3}$ (cylindrical)

ADMX-VERA cavities with high volumes

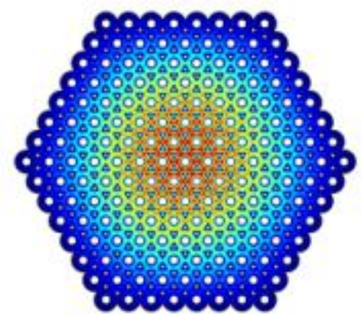




Single and triple wedge cavity **[2]** resonant frequencies depend only on the width of the volume space

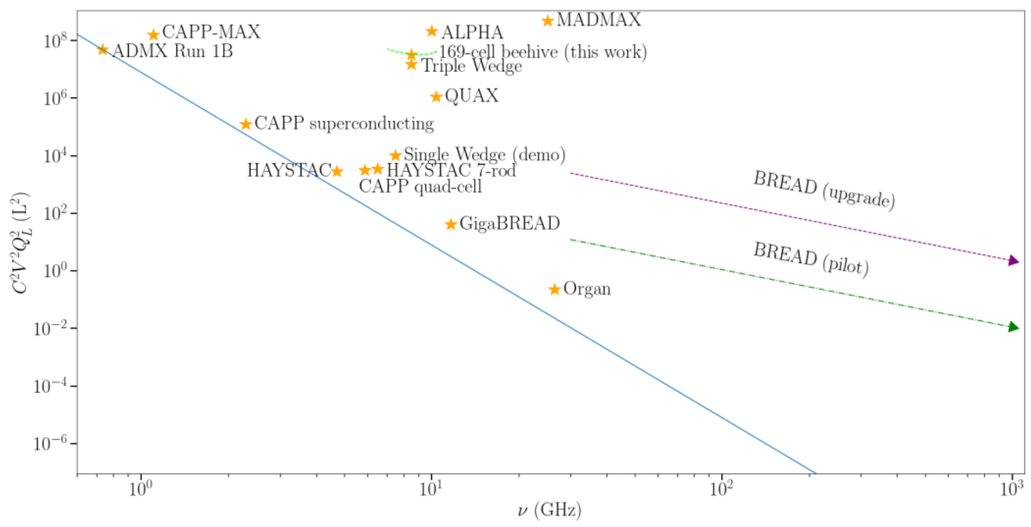
$$\frac{d\nu}{dt} \propto V^2$$

$n = 169$



Multiple-cell beehive cavity that share the resonant frequency among all cells **[3]**

Advantages of ADMX-VERA cavities



Cavity-based figure of merit for multiple experiments

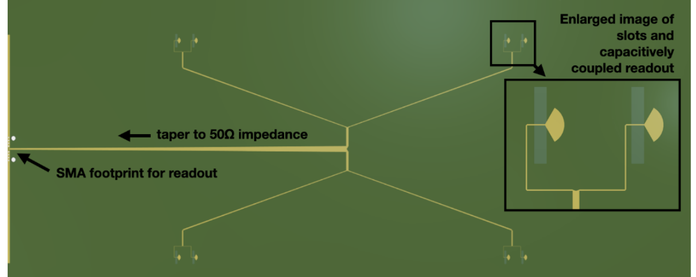
Challenges of the thin shell cavity

$$\frac{d\nu}{dt} \propto \left(\frac{\beta}{1+\beta}\right)^2$$ Max at $\beta = 2$

Misalignment in cavity can localize modes and limit wire antenna coupling

Summing trees can coherently add signals through impedance matching from multiple slot antennas

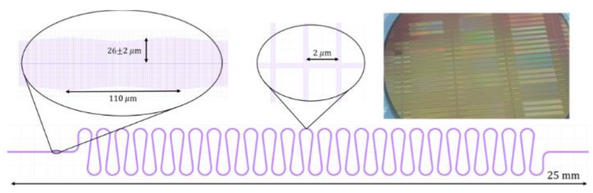
(Used in CMB experiments before **[4]**, but will be the first time in axion searches)



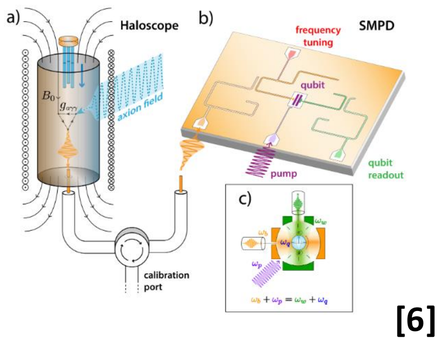
Basic summing tree structure for eight slot antennas

Quantum sensors

$$\frac{d\nu}{dt} \propto T_{\text{sys}}^{-2}$$



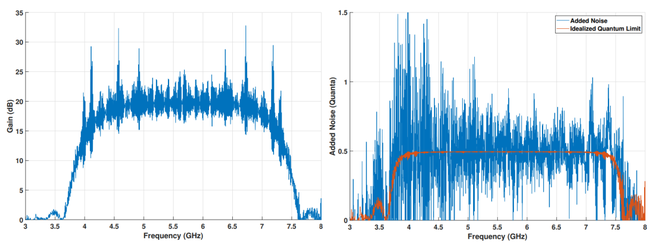
Kinetic inductance travelling-wave parametric amplifiers (KI-TWPAs)



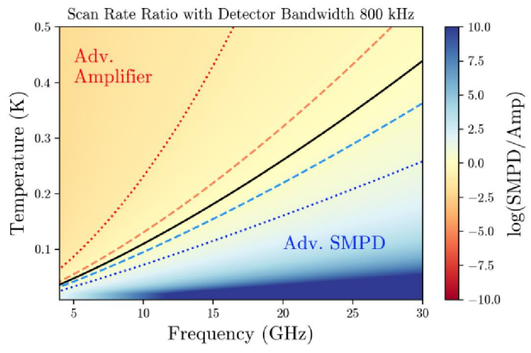
[6]

Single microwave photon counting devices (SMPDs)

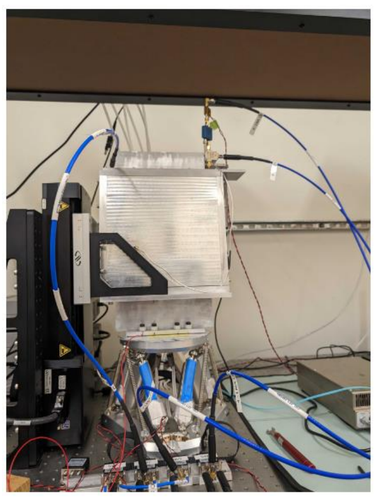
Axion converted photons excite qubit circuit, frequency tunable



KI-TWPA measurements **[5]**
Left: High gain, 3 GHz bandwidth
Right: Added amplifier noise (blue) is close to quantum limit (orange)

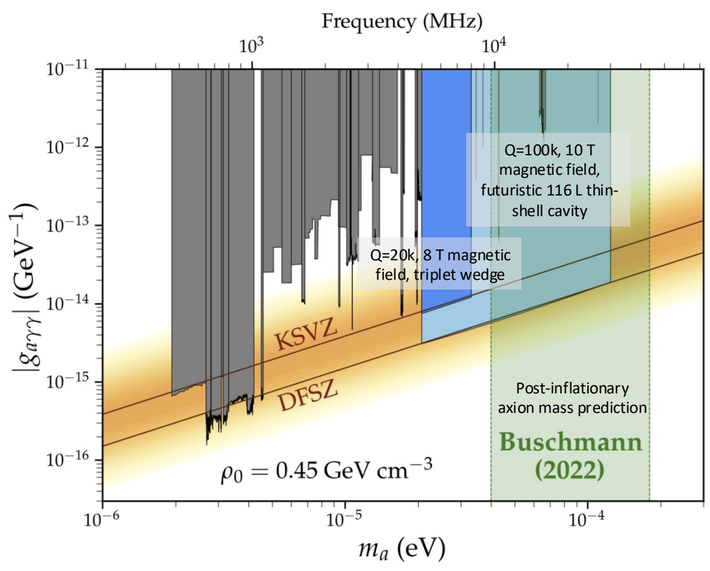


Current progress and discovery potential



Data taken for warm single-wedge cavity dark photon search and now in analysis phase

Cyrogenic single-wedge cavity characterization is also in progress



Future axion discovery potential of ADMX-VERA

[1] https://cajohare.github.io/AxionLimits/
[2] T. Dyson et al., Phys. Rev. Applied 21, L041002 / Triple Wedge work done by Sephora Ruppert
[3] Matthew O. Withers and Chao-Lin Kuo, arXiv:2404.06627
[4] Chao-Lin Kuo et al., Millimeter and Submillimeter Detectors and Instrumentation for Astronomy IV, 7020, 415–428. SPIE, (2008)
[5] Klimovich, Nikita Sergeevich (2022) Traveling Wave Parametric Amplifiers and Other Nonlinear Kinetic Inductance Devices. Dissertation (Ph.D.), California Institute of Technology
[6] C. Braggio et al., arXiv:2403.02321

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