DMRadio-50L Experiment Status and Overview

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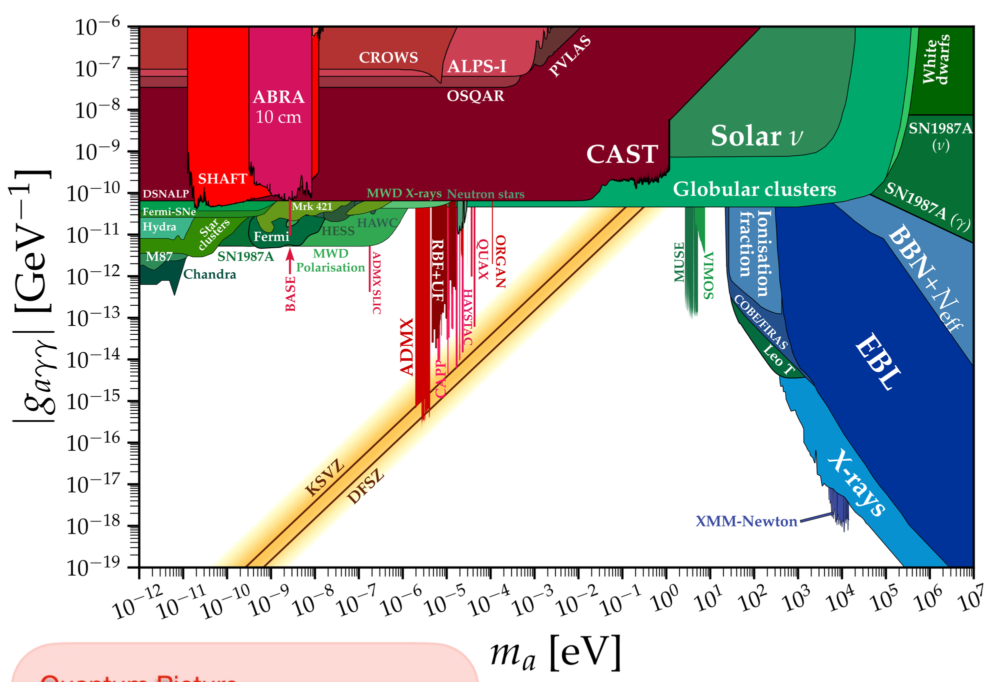
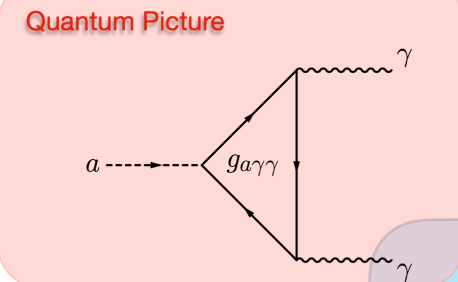
Axion Background

- Axions Dark Matter candidate originally used to solve strong-CP problem
- 13 orders of magnitude of mostly unexplored parameter space
- Cavity experiments (ADMX/HAYSTAC/CAPP etc..) have only probed a near ~ 1 GHz
- Other experimental techniques required in order to probe other frequencies/masses
- DMRadio experiments use lumped-element detectors with a quantum sensor readout
- Treat the quantum interaction of the axion in a classical picture



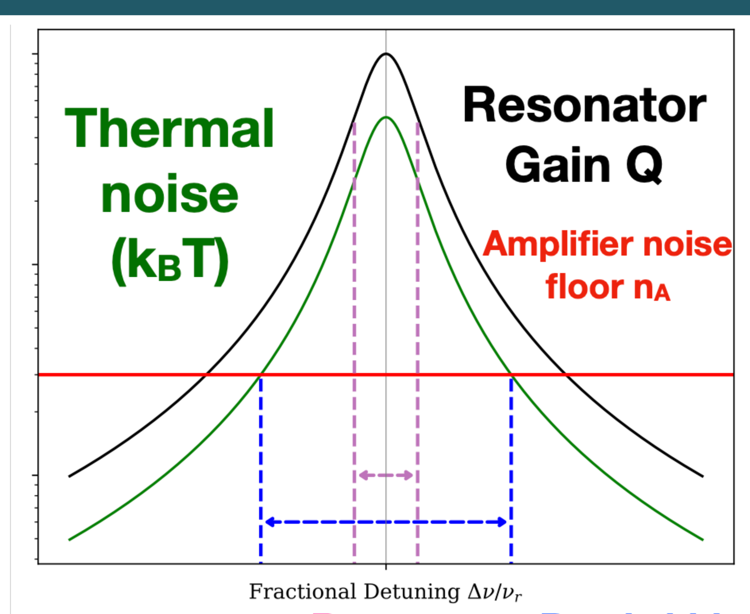


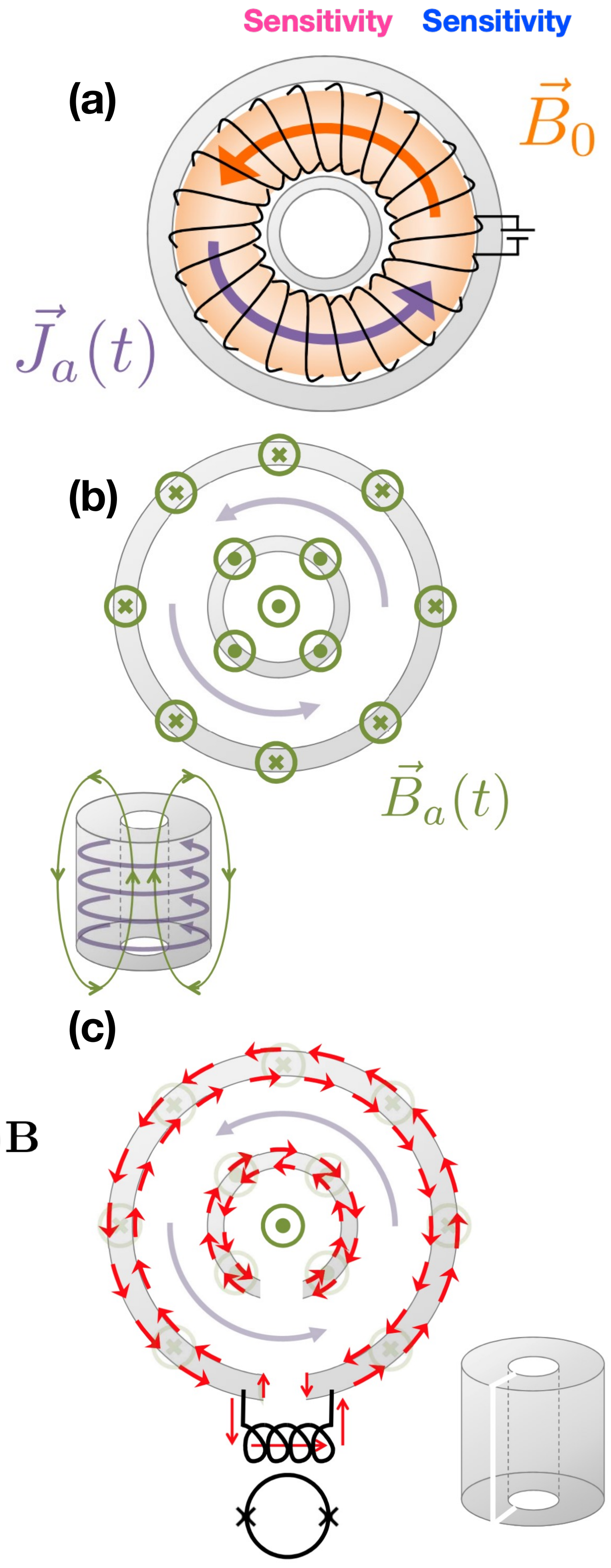
Classical Picture

$$\nabla \cdot \mathbf{E} = -g_{a\gamma\gamma}\mathbf{B}\cdot\nabla a$$
$$\nabla \cdot \mathbf{B} = 0$$
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$
$$\nabla \times \mathbf{B} = \frac{\partial \mathbf{E}}{\partial t} - g_{a\gamma\gamma}\left(\mathbf{E}\times\nabla a - \frac{\partial a}{\partial t}\mathbf{B}\right)$$

Lumped Element Detection for Low-Mass Axions

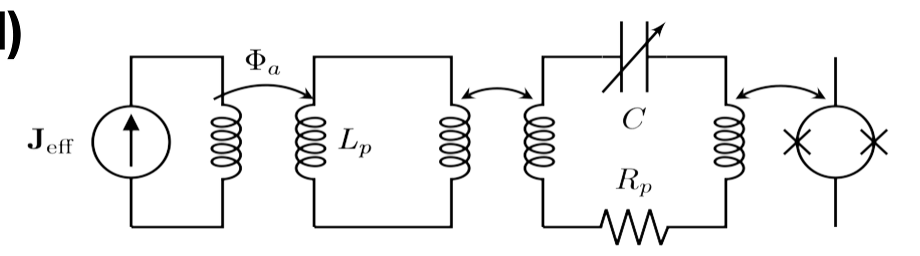
- The physical signal we are looking for is generated via Primakoff effect
- Axion signal inductively coupled via tunable LC circuit
- Readout performed via SQUID/LC readout chain
- Detector bandwidth optimization maximizes SNR/scan rate
- Axion signal procedure:
  - **(a)** Static Magnetic Field B_0 induces an oscillating axion current $J_a(t)$
  - **(b)** $J_a(t)$ generates an additional magnetic field $B_a(t)$ perpendicular to the original field
  - **(c)** $B_a(t)$ generates screening currents on inner surface of sheath
  - We inductively couple to these screening currents
- Entire process can be written as equivalent circuit design **(d)**



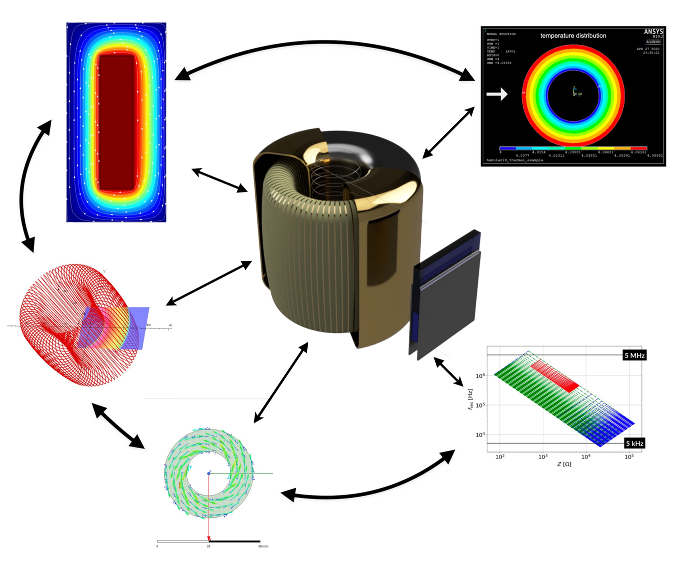


$$J_{eff} = g_{a\gamma\gamma}\partial_t a\mathbf{B} \approx g_{a\gamma\gamma}\sqrt{2\rho_{DM}}cos(m_a t)\mathbf{B}$$

(d)

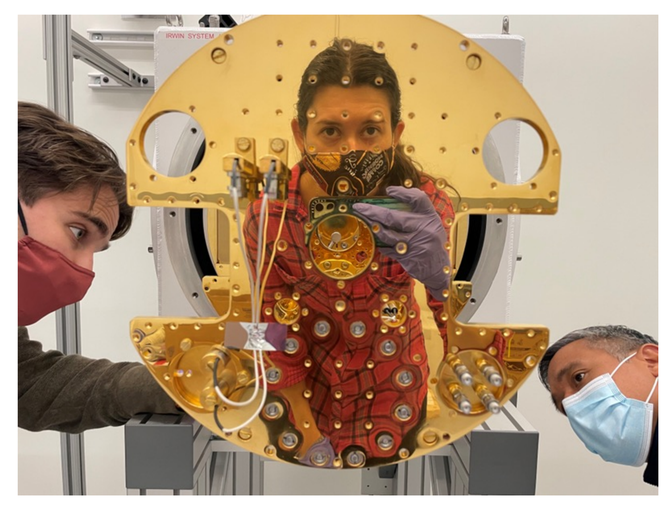


Current Status



Above: Various components of the DMRadio optimization campaign that informed the design decisions

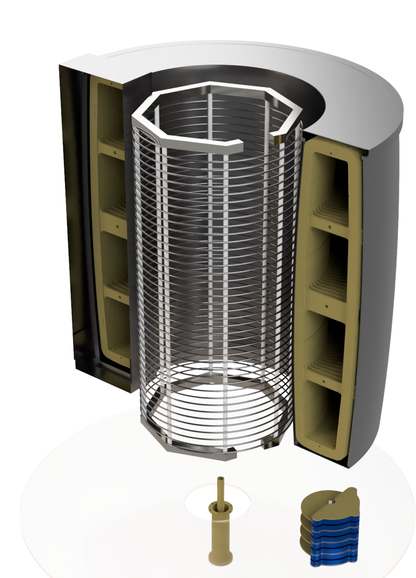
Below: Installation of dilution refrigerator at Stanford (Photo credit Maria Simanovskaia)

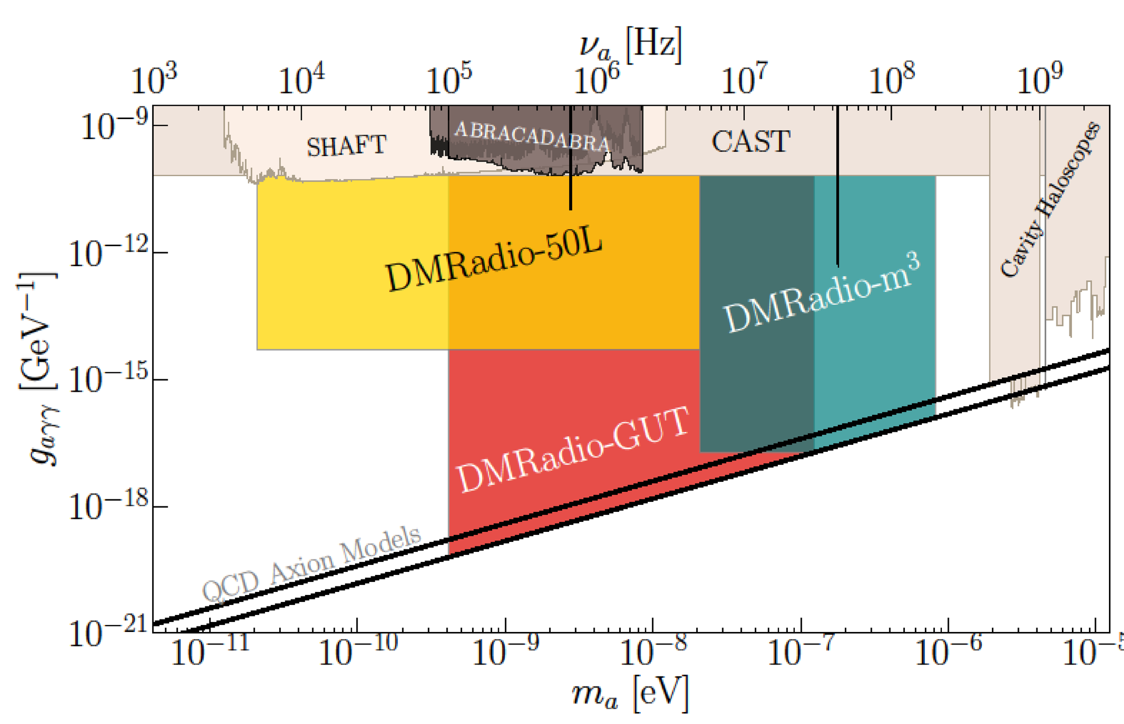


- Currently finishing design optimization campaign
- Dilution refrigerator operational
- Magnet construction by Superconducting Systems Inc.
- Detector package in final design
- Testing and installation of subsystems
  - Calibration – see Poster by Jessica Fry
  - SQUID package
  - Detector package
  - Detector – Cryostat Interface
- Assembly of full experiment by mid-2024

Parameter	Design Spec
Peak Field	1 Tesla
Sensitivity Region	5 kHz - 5 MHz
Science Volume	50 Liters

DMRadio 50L Sensitivity Reach





- DMRadio-50L will go down to $g_{a\gamma\gamma} \sim 5 \times 10^{-15}$ GeV^{-1} between 5 kHz and 5 MHz
- We are finalizing design campaign
- Beginning assembly process now
- Data taking to start in mid-2024
- DMRadio-50L will also serve as a testbed for quantum sensor technology
- Provide experiment for future experiments such as DMRadio-m3 (see poster by N. Rapidis) and DMRadio-GUT

For More Information on DMRadio Refer to:

(a) (b) (c) (d)

Other DMRadio Posters here at UCLA Dark Matter:

- DMRadio-m3: an overview by Nicholas Rapidis
- Calibrating the DMRadio-50L Detector by Jessica Fry

See also: *Low Mass Axion Searches from ABRACADABRA Results to the DMRadio Program* by Maria Simanovskaia Saturday 8:30 am

Recent DM Radio Publications:

- S. Chaudhuri et al., "Optimal Impedance Matching and Quantum Limits of Electromagnetic Axion and Hidden-Photon Dark Matter Searches" **(a)**
- A. AlShirawi et al., "Electromagnetic modeling and science reach of DMRadio-m3" **(b)**
- L. Brouwer et al., "Projected Sensitivity of DMRadio-m3: A Search for the QCD Axion Below 1μeV" **(c)**
- L. Brouwer et al., "Proposal for a definitive search for GUT-scale QCD axions" **(d)**
- C. Bartram, et al., "Noise limits for dc SQUID readout of high-Q resonators below 200 MHz", In preparation

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