

DMRadio Program: Strategy Towards the GUT-Scale

October 2025

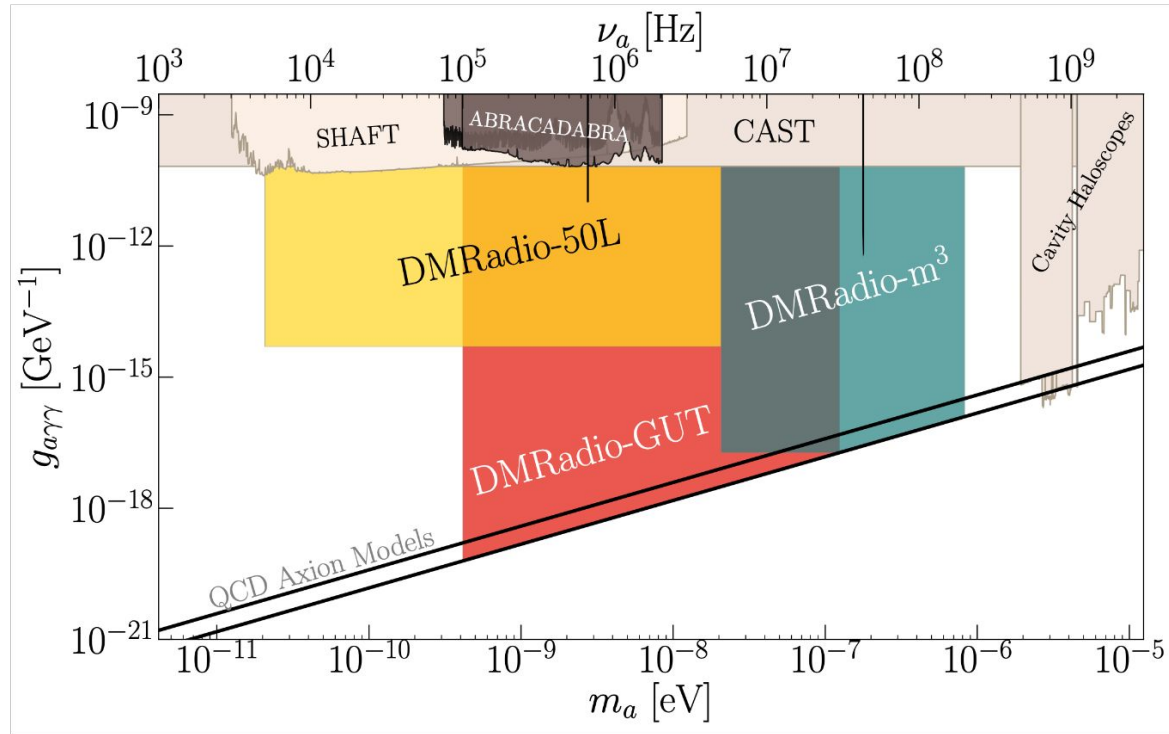
50L First Results Planning

Seminars at all institutions

Zoom Seminar with Multiple Presenters

Conferences - We need a full speakers board now.

The DMRadio Program

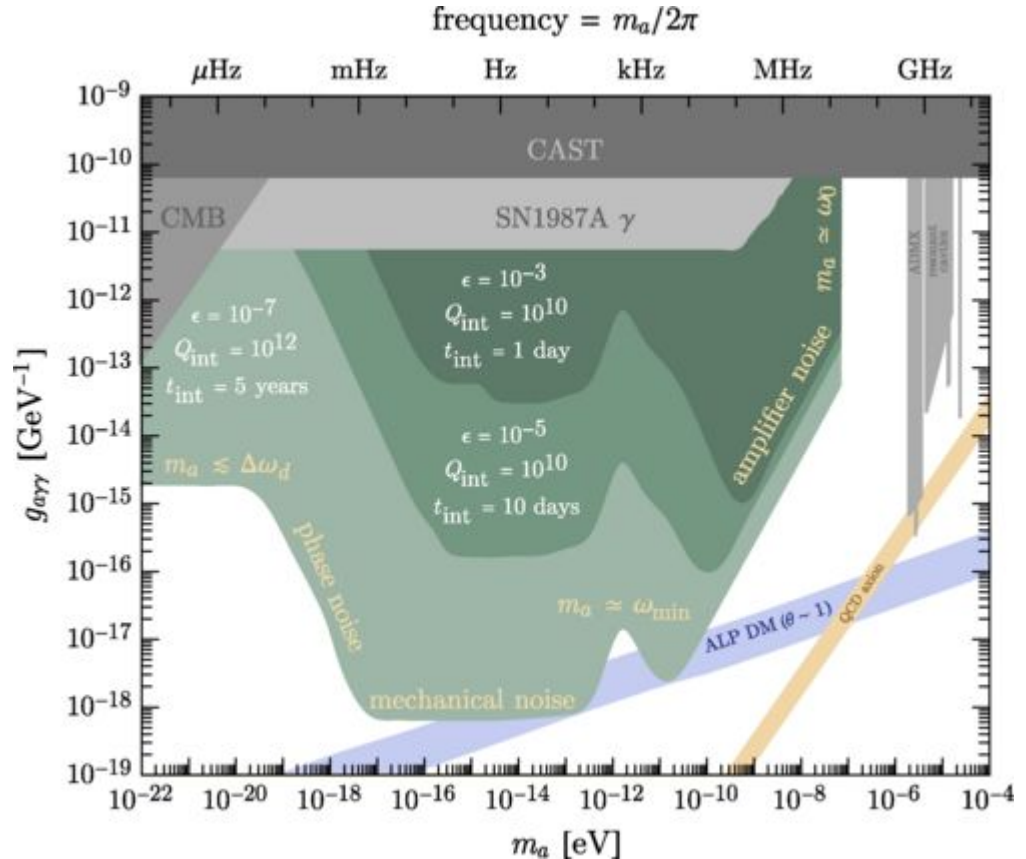


A program to make a definitive search for GUT-scale axions and find a pre-inflation relic.

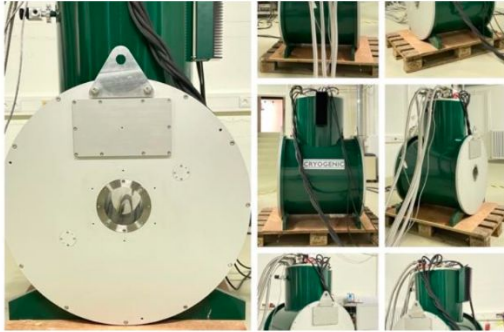
SRF Cavities

We have known about this effort at Fermilab as part of their quantum center (SQMS).

Earlier limits made the technique look more promising in the DMRadio region.



WISPLC – Broadband & Resonant Searches



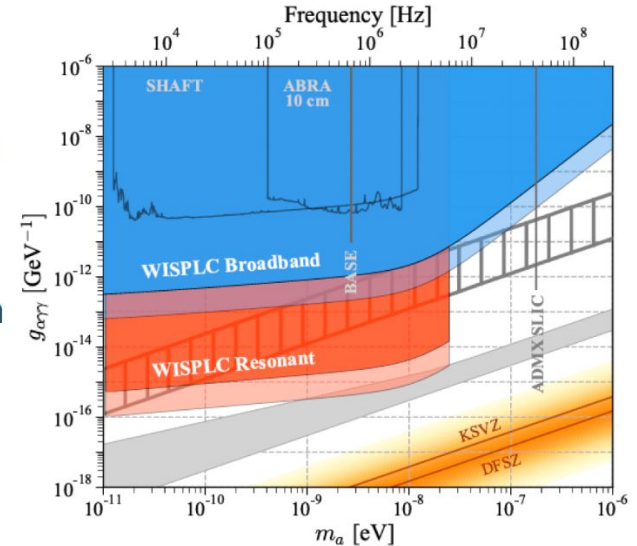
Warm-bore superconducting solenoid magnet with $B = 14$ T.

Broadband case:

- Pickup coil of inductance L connected with a LNA.
- Measurement frequency range limited by stray capacitance.

Resonant case:

- Tunable capacitor connected in series.
- $Q = \frac{\omega}{\Delta\omega}$ improvement of the signal at $\omega = \frac{1}{\sqrt{LC}}$

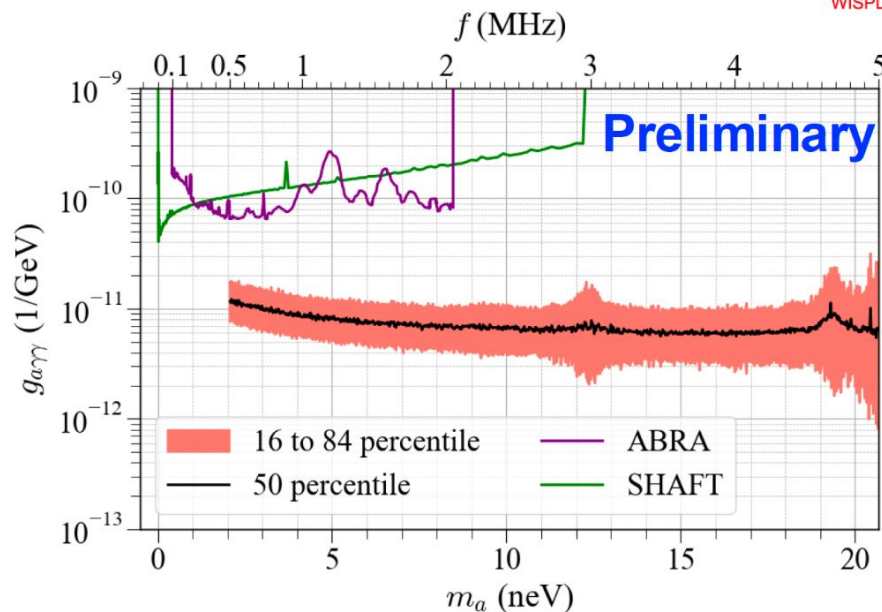


WISPLC – Prototype Results

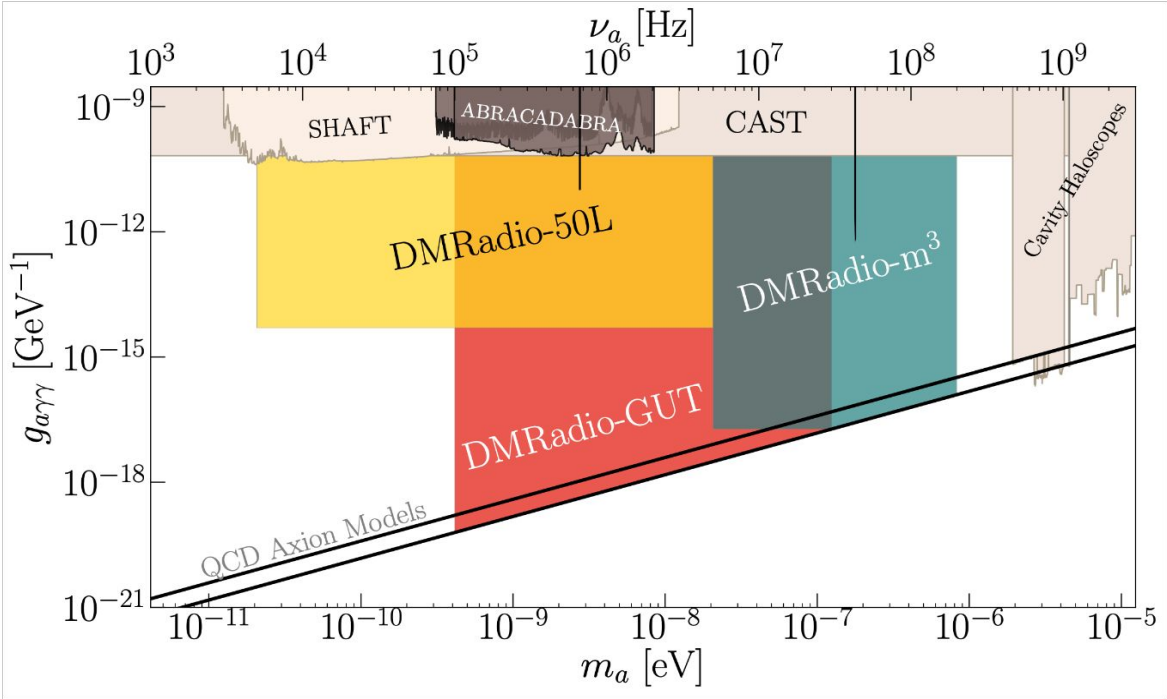


- Analysis of 1st run ≤ 5 MHz for efficient parasite masking.
- Data acquisition for **measurement loop**: 72 h in B = 6T, 24 h in B = 3T, 24 h in B = 0T.
- Data acquisition for **external probe**: 12 h in B = 6T, 12 h in B = 3T, 12 h in B = 0T.
- **No persistent ALP signal** in the collected dataset.
- Excluded couplings $g_{a\gamma\gamma} \geq 5.42 \cdot 10^{-12} \text{ GeV}^{-1}$ for axion masses between **2 - 20.7 neV**.

$$g_{a\gamma\gamma} = \frac{\text{SNR } \sigma_{\Phi} (t\tau_a)^{-1/4}}{BV_B \sqrt{2\rho_{DM}}} = \frac{\text{SNR } \sigma_V (t\tau_a)^{-1/4}}{m_a GN_{loop} BV_B \sqrt{2\rho_{DM}}}$$



The DMRadio Program



How do we scale? \$2M, \$20M, \$200M

DMRadio Collaboration

C. Bartram, H. M. Cho, W. Craddock, K. D. Irwin, D. Li, W. J. Wisniewski, A. K. Yi
SLAC National Accelerator Laboratory

V. Ankel, C. Bell, J. Corbin, P. Graham, K. D. Irwin, A. Kunder, N. M. Rapidis, M. Simanovskaia, J. Singh, P. Stark, E. C. van Assendelft, K. Wells, D. Wright
Stanford University

A. Droster, J. Echevers, A. Keller, S. Puranam, C. P. Salemi, K. van Bibber, C. Virador
University of California Berkeley

L. Brouwer
Lawrence Berkeley National Lab

B. A. Young
Santa Clara University

J. T. Fry, K. M. W. Pappas, K. Vetter, L. Winslow
Massachusetts Institute of Technology

J.-M. Begin, S. Chaudhuri, R. Kolevatov, N. Otto, J. Wiedemann
Princeton University



Collaboration

We are 6 research institutions and 6 PIs (counting has some uncertainty).

There is a rough rule of thumb of \$1M per PI, may be with inflation that grows to \$3M per PI, which puts us roughly at the scale of the DMRadio-m³ project.

We are going to need to grow for the \$200M project.

International Context

Korea continues to be focussed at higher frequencies and money to the axion institute is not as large as a few years ago.

Australia continues to be a wild card but does not have the ability to fund an experiment at the scale of GUT.

Italy has a small group out of Frascati (FLASH), I need to find out about a network of high frequency gravitational wave detectors.

Spain has leadership in IAXO.

Germany has resources and DESY has interest.

CERN has magnet expertise, but their focus is FCC.

Near Term R&D

2026

2030

2040



DMRadio-50L



Toroidal Geometry w/Sheath, Quantum Sensing

Quantum

PXS



Solenoid Geometry, High Frequency Readout,
NbTi (HTS magnet R&D also happening)

PPPL Buy In

CAL Demonstrator



Solenoid Geometry, Low Frequency Readout

LBL Buy In

Core Demonstrator



Core Geometry, Low Frequency Readout

SLAC Buy In

ABRA Demonstrator



Novel analyses, RFSoc readout and triggering.

AI/ML

Path to DFSZ at neV

2026

2030

2040



Meter-cubed-scale



DMRadio-GUT

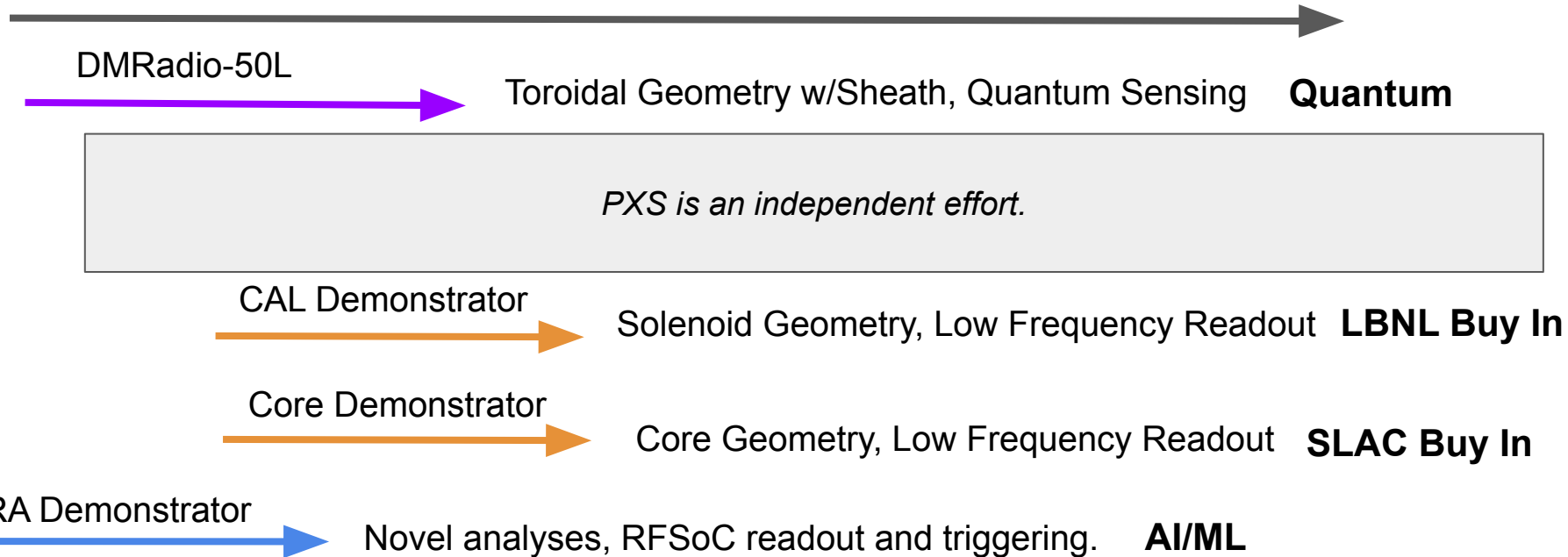


We need to develop a plan for staffing the demonstrators:

2026

2030

2040



Challenges

- Tight funding environment
 - NSF groups need results every year.
 - Early career folks need cohesive projects with identifiable leadership.
 - Alignment with Quantum + AI/ML initiatives => can we add micro-electronics?
- Uneven resources including access to national labs and foundations.
- Divided Attention
- Outside individuals and groups.