THE DARK MATTER RADIO PATHFINDER

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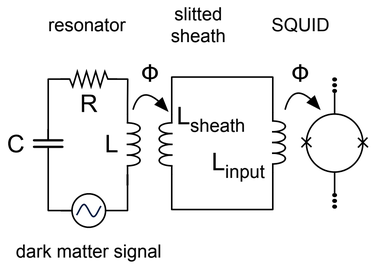
INTRODUCTION AND MOTIVATION



- Growing interest in **searching for wave dark matter candidates** due to a lack of WIMP detection or signatures of supersymmetry.
- **The Dark Matter Radio (DM Radio)** will search for sub-eV axion and hidden photon dark matter over a wide mass range.
- DM Radio detector consists of a **superconducting, tunable lumped-element LC resonator** with SQUID-based readout.
- **DM Radio Pathfinder** has the ability to detect hidden photon dark matter and **informs scaling to larger experiments.**

WAVE DARK MATTER CANDIDATES

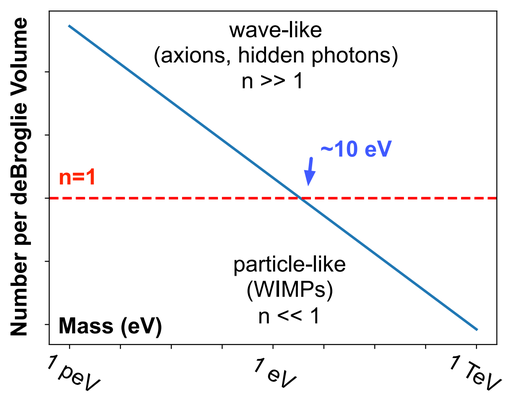
Candidate	Spin	Production Mechanism	Coupling
QCD Axion/ALP	0 (pseudoscalar)	Misalignment mechanism	Inverse Primakoff effect $g_{\alpha\gamma\gamma}$
Hidden Photon	1 (vector)	Inflationary fluctuations,[5] misalignment mechanism	Kinetic mixing ε

- Local dark matter density (~0.4 GeV/cm^3) **requires light fields to be bosonic.**
- **Oscillation frequency determined by rest mass** (hf=mc^2) plus small contribution from kinetic energy.
- Kinetic energy from virialized dark matter sets f/Δf ~ 10^6, **field is coherent within detector!**
- Hidden photons/axions act an **oscillating background current density** sourcing a real, oscillating electromagnetic field.

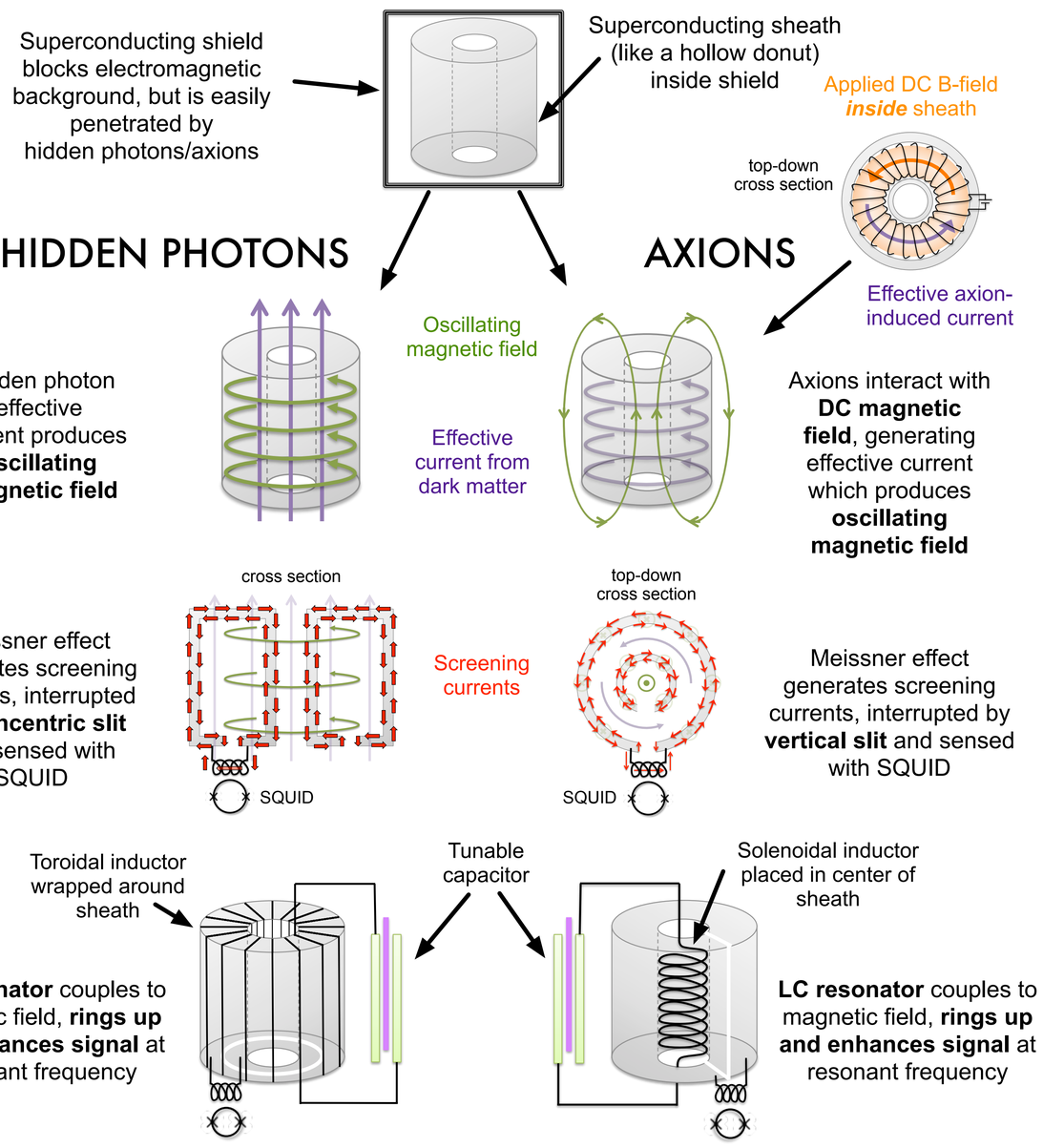
$$f \approx 2.5\,\mathrm{MHz} \times (m/10^{-8}\,\mathrm{eV})$$

$$t_{\mathrm{coherence}} \approx 0.4\,\mathrm{s} \times (10^{-8}\,\mathrm{eV}/m)$$

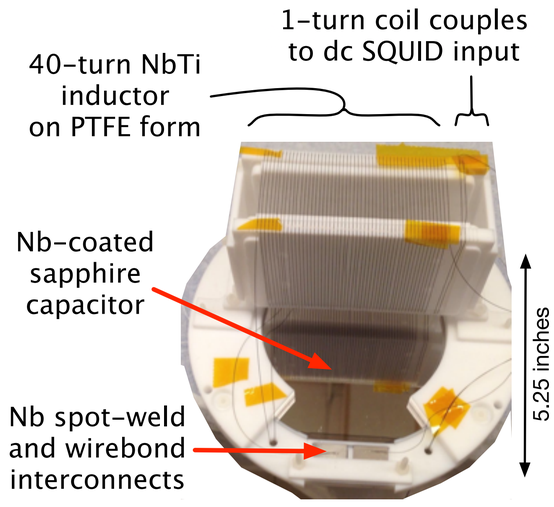
$$\lambda_{\mathrm{coherence}} \approx 100\,\mathrm{km} \times (10^{-8}\mathrm{eV}/m)$$

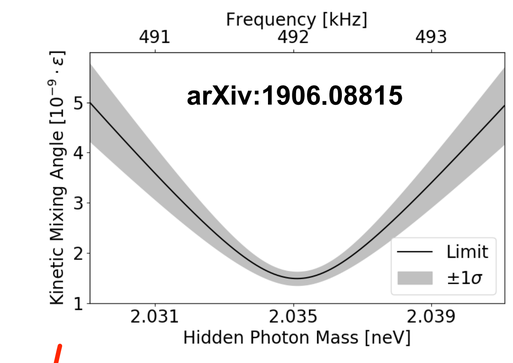


DETECTION TECHNIQUE



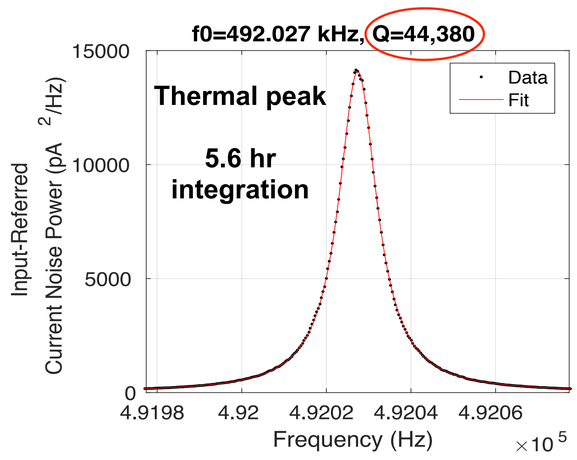
FIXED-FREQUENCY RESONATOR



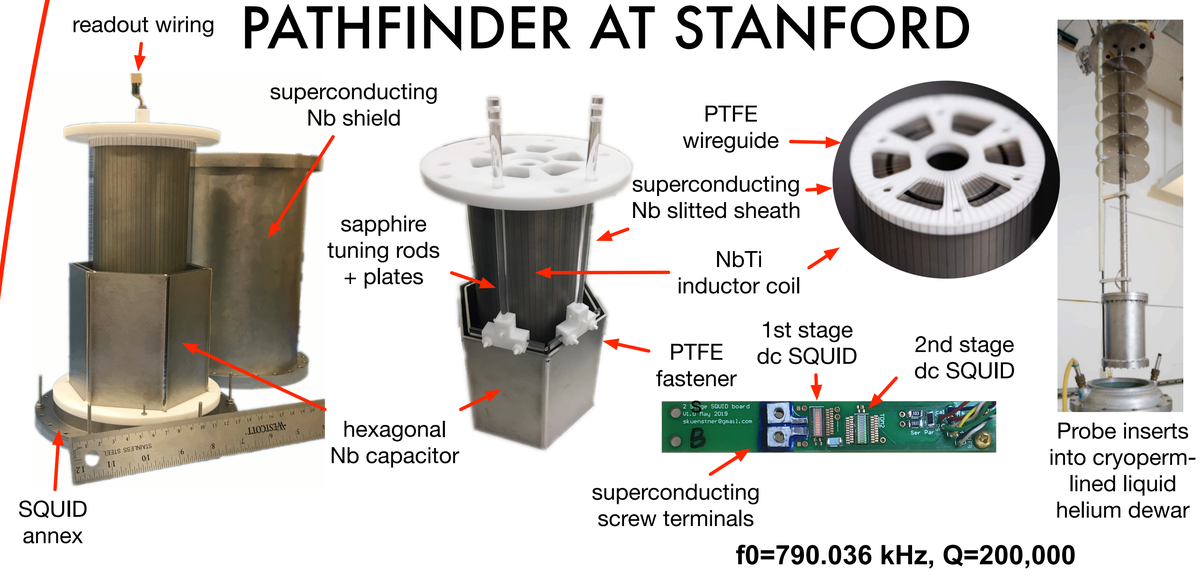


- Single-frequency test resonator with **sensitivity to hidden photon dark matter** (100 mL volume)
- **No excess power observed** in 5.6 hr search integration
- **First direct detection limits on hidden photons** in the neV mass range!

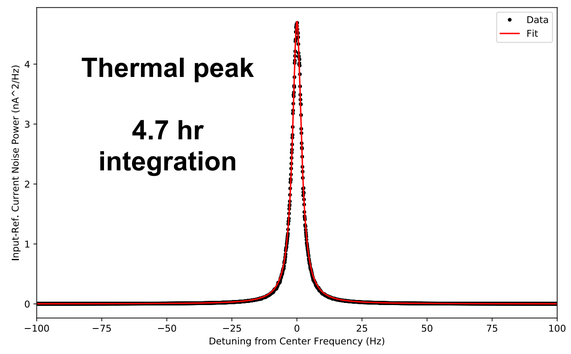
Comparable to copper microwave cavities!



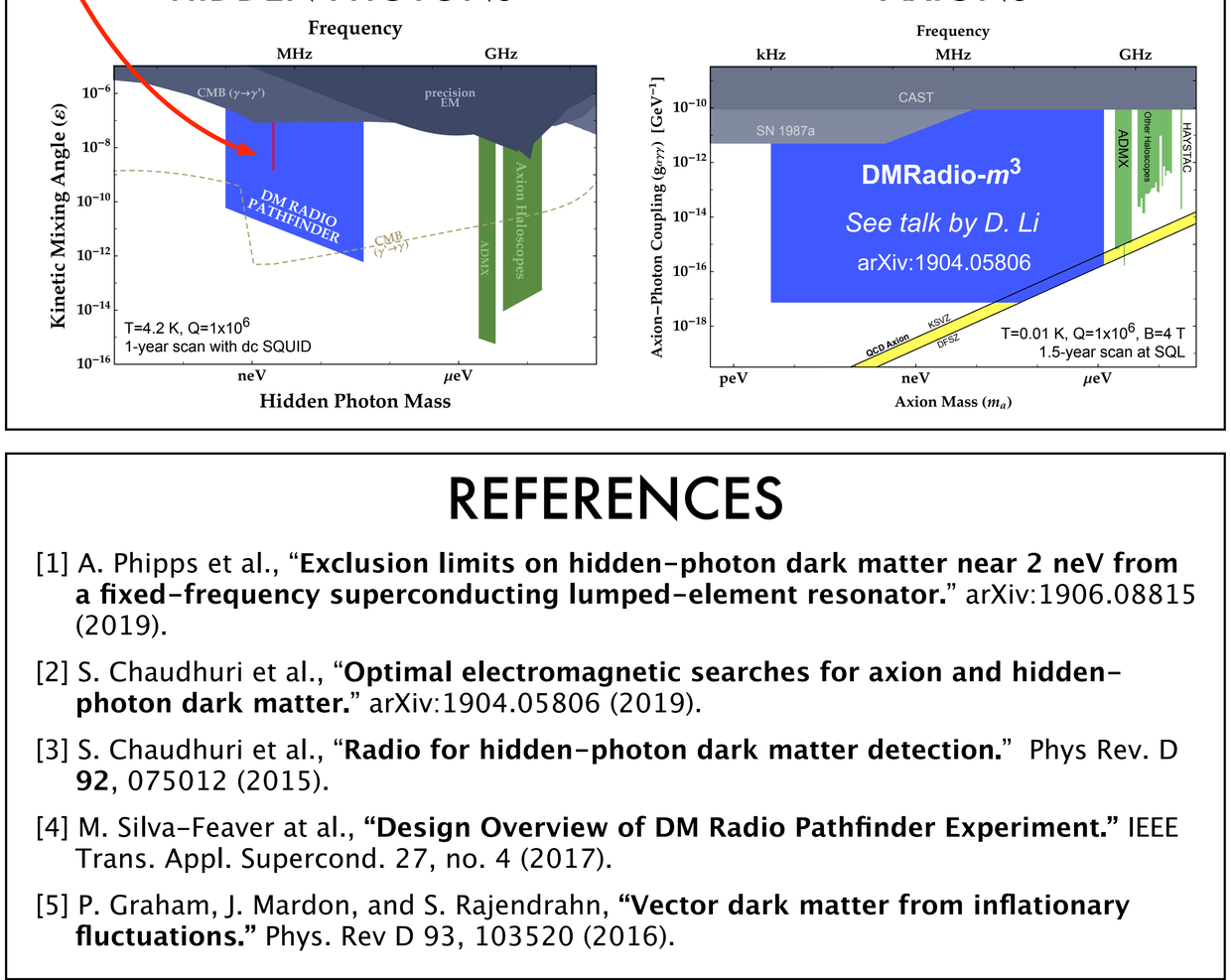
PATHFINDER AT STANFORD



- **670 mL hidden photon detection volume**, will cover 100 kHz – 10 MHz in full scan
- Operates in liquid helium, **tuning performed by position of sapphire dielectric plates**
- **Initial Q=200,000**, determined by overcoupled SQUID



PROJECTED SENSITIVITY



REFERENCES

[1] A. Phipps et al., "**Exclusion limits on hidden-photon dark matter near 2 neV from a fixed-frequency superconducting lumped-element resonator.**" arXiv:1906.08815 (2019).

[2] S. Chaudhuri et al., "**Optimal electromagnetic searches for axion and hidden-photon dark matter.**" arXiv:1904.05806 (2019).

[3] S. Chaudhuri et al., "**Radio for hidden-photon dark matter detection.**" Phys Rev. D **92**, 075012 (2015).

[4] M. Silva-Feaver at al., **"Design Overview of DM Radio Pathfinder Experiment."** IEEE Trans. Appl. Supercond. 27, no. 4 (2017).

[5] P. Graham, J. Mardon, and S. Rajendrahn, **"Vector dark matter from inflationary fluctuations."** Phys. Rev D 93, 103520 (2016).