The DM Radio Pathfinder experiment: searching for dark matter from 500 peV to 50 neV

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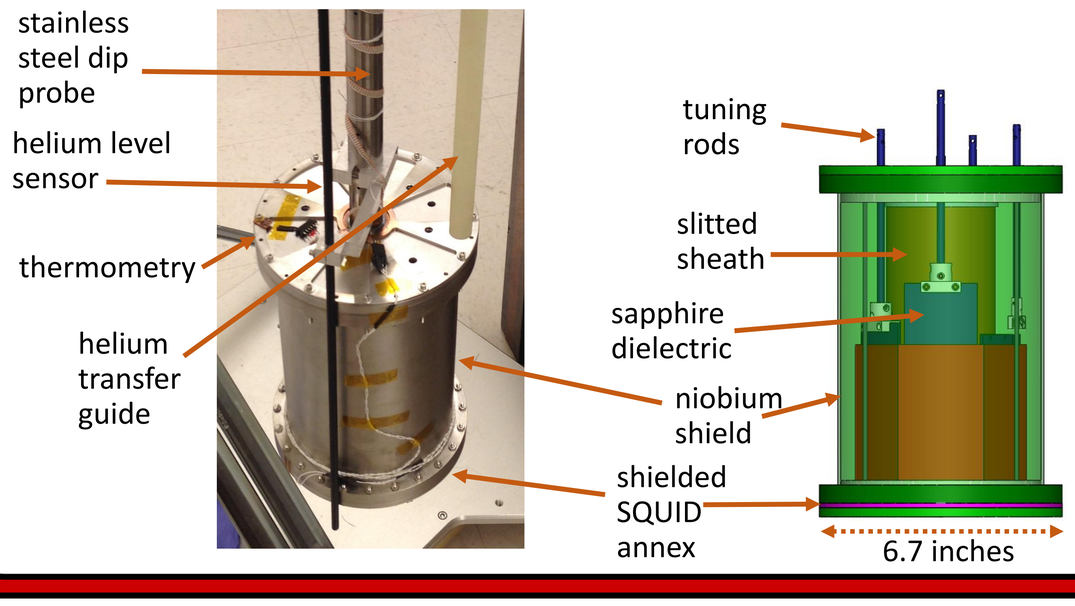
DM Radio hidden photon coupling

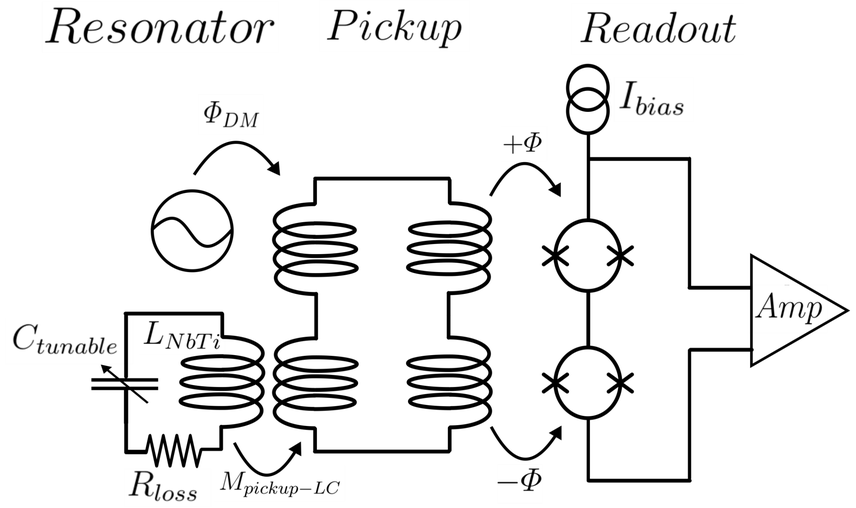
- A toroidal sheath couples to the magnetic field generated by hidden photons, which oscillates at a frequency set by the dark matter mass. For more details, see A. Phipps, PE-15.
- A slit in the sheath diverts the screening currents in the sheath to the input coil of a SQUID amplifier.
- A Nb-Ti wire-wrap inductor and parallel-plate niobium capacitor with removable sapphire dielectric form a high quality-factor, tunable, lumped-element resonator.

Detector design



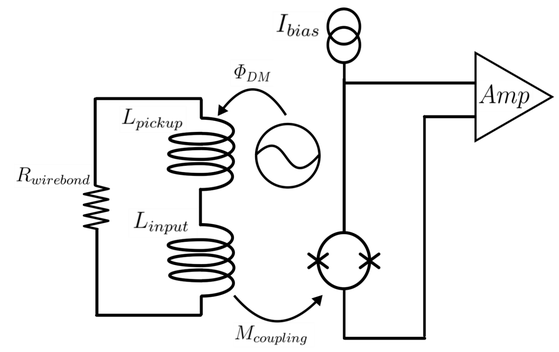
Readout Circuit

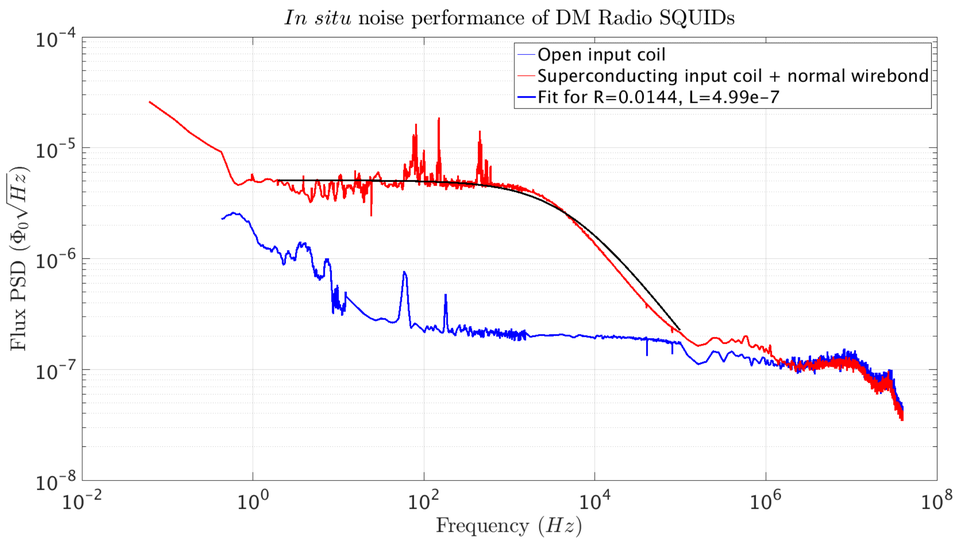
- The dark matter signal couples magnetic flux into the slitted sheath, which is modelled as a lumped-element inductor.
- The resonator and pickup circuits are connected to the input coil of a balanced pair of DC SQUIDs for differential amplification and readout.



Pathfinder Engineering Runs

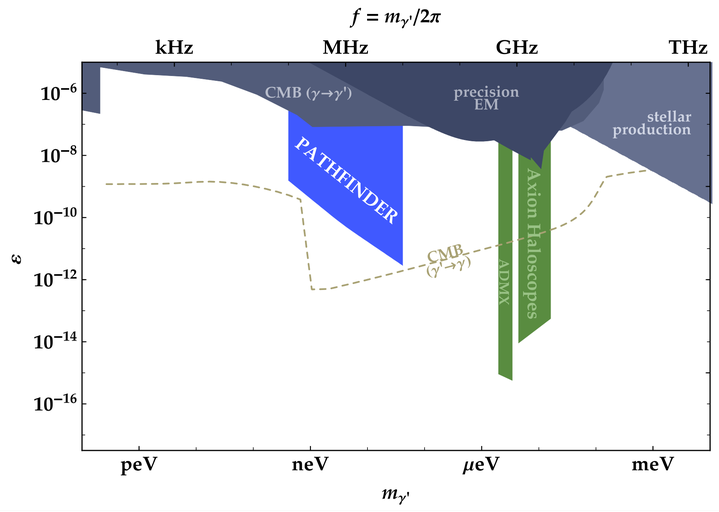
- Preliminary engineering runs have been conducted without resonator to verify the electrical and mechanical design, electromagnetic shielding, and *in situ* noise performance of the SQUID amplifier.
- The bare SQUIDs have a white noise floor of $0.2\ \mu\Phi_0/\sqrt{Hz}$ at 4K.
- Coupling to SQUID determined by measuring Johnson noise from a normal aluminum wirebond, as shown in the schematic below:





Pathfinder Sensitivity

- The pathfinder experiment will probe two decades of mass, and set new model-independent limits on hidden photons.
- The full experiment will have much larger reach. For more details, see A. Phipps, PE-15.

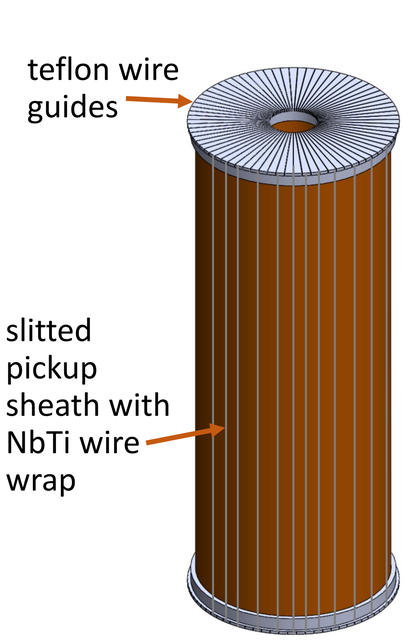


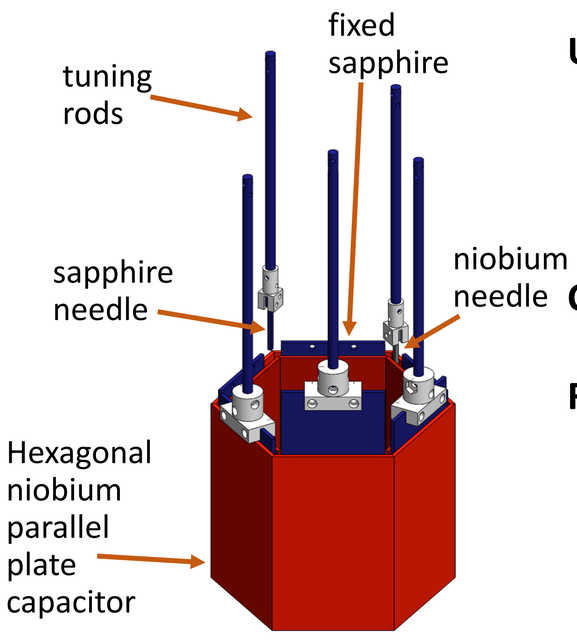
Tunable Resonator

- Over the summer the resonator will be implemented in a series of runs.
- The resonator enhances the search sensitivity by coherently accumulating energy from the dark matter field, over a timescale set by the coherence properties of the dark matter field:

$$T_{coherence} \approx \left(\frac{v_{virial}}{c}\right)^2 \frac{2\pi}{\omega_{DM}}$$

- See S. Chaudhuri, PE-24 for full sensitivity analysis.





Ultra-coarse tuning (tunable between runs)
- fixed sapphire plate fully inserted/removed (tune C)
- change number of turns in solenoid coil (tune L)

Coarse tuning (tunable *in situ*)
- position of sapphire dielectric plates (3)

Fine tuning (tunable *in situ*)
- position of sapphire needle
- position of niobium needle

References

- Chaudhuri et al., **Radio for hidden-photon dark matter detection** Phys. Rev. D 92, 075012 (2015) / arXiv:1411.7382
- Silva-Feaver et al., **Design Overview of the DM Radio Pathfinder Experiment** arXiv:1610.09344 (ASC 2016 Conference Proceeding)
- Graham, Mardon, and Rajendran, **Vector dark matter from inflationary fluctuations** Phys. Rev. D 93, 103520 (2016) / arXiv:1504.02102

Acknowledgments

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