Magnet R&D for Low-Mass Axion Searches

Snowmass Planning Meeting - AF5 Session
October 6th, 2020

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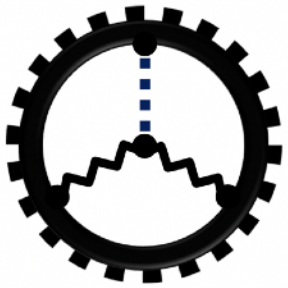

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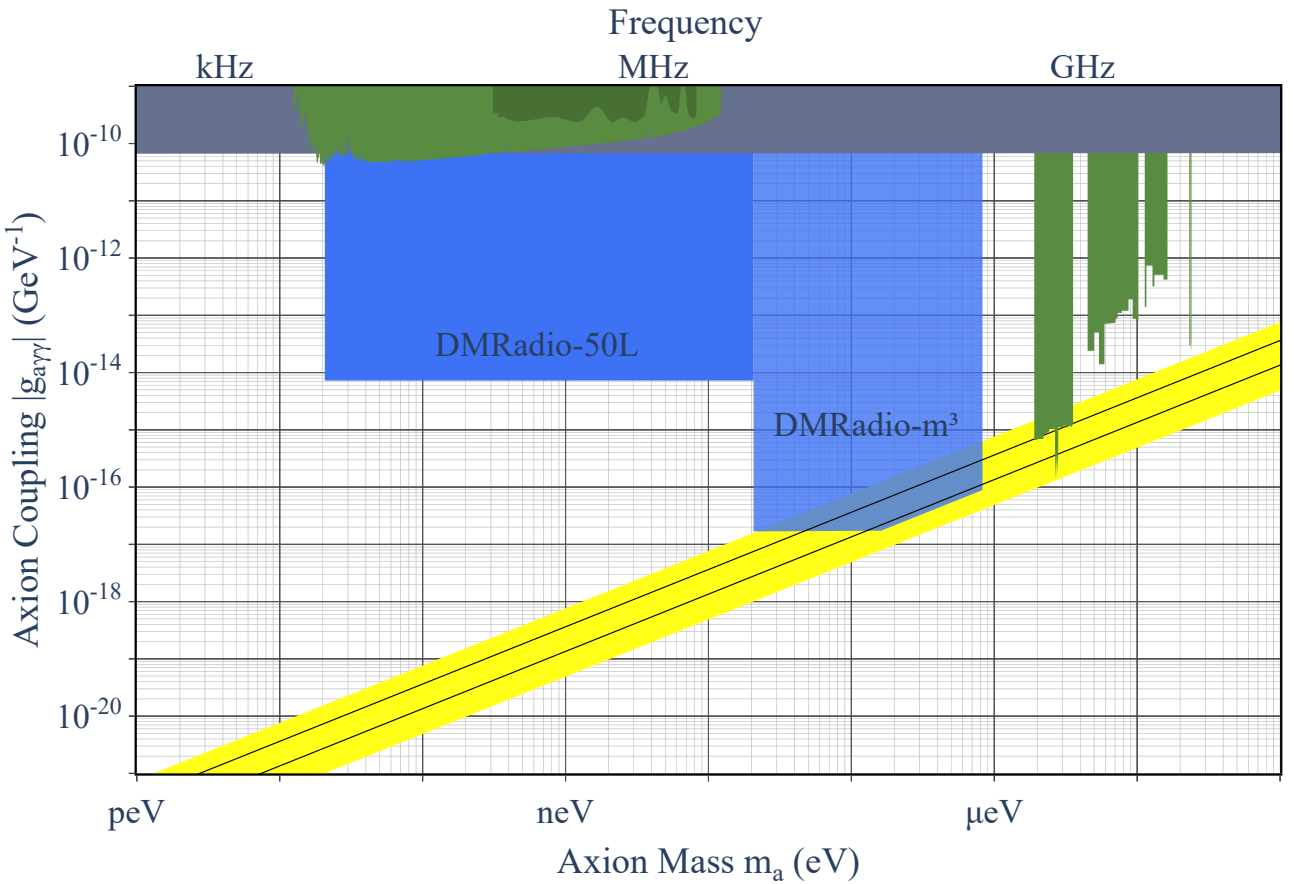
Introduction/Overview

- The axion as a Dark Matter candidate couples to detectors via magnetic fields throughout the detector volume
- Sensitivity depends on many factors and scales as:

$$g_{a\gamma\gamma}^{-1} \propto \frac{B_0 V^{\alpha} Q^{1/4}}{\eta^{1/4} T^{1/4}}$$

- The axion parameter space is currently wide open over 12 orders of magnitude in mass
- We have divided up this parameter space into various regions where different technologies are optimal



For more details on the DM Radio Family of experiments - please see talks in CF2 breakout session

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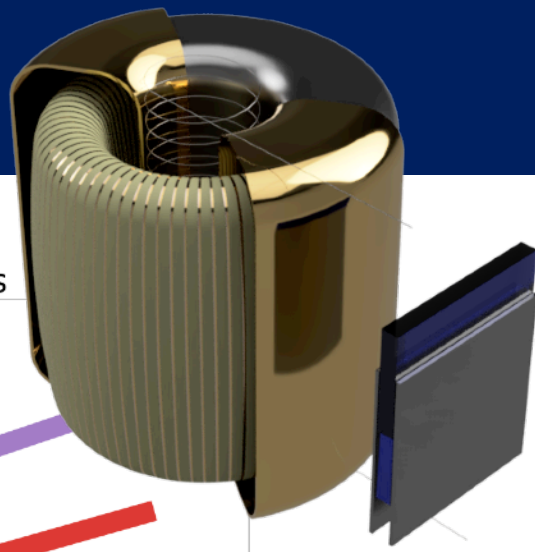
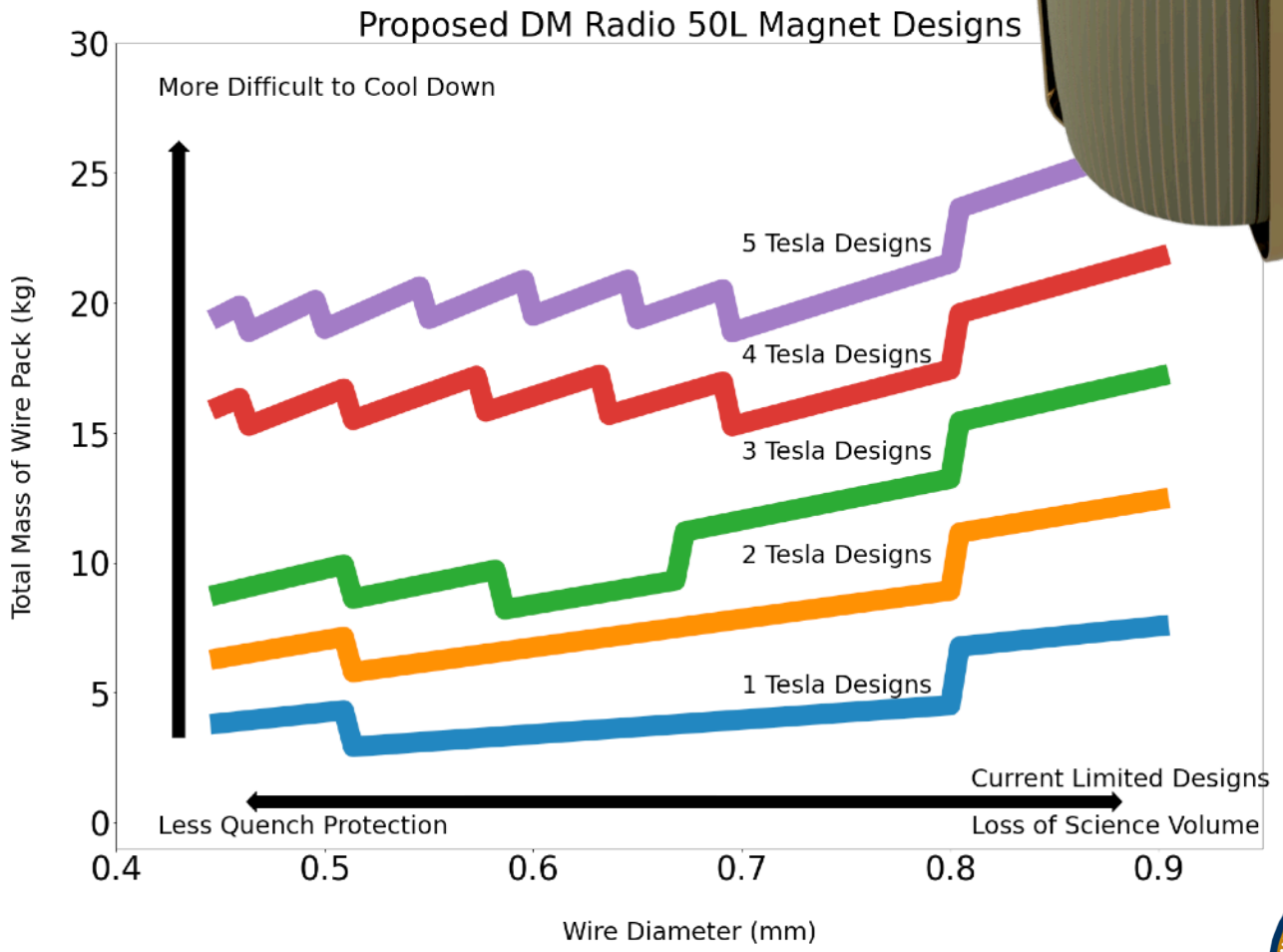
The Magnet Design Process

- Up until now, all axion dark matter experiments have utilized commercial magnet designs
- However; our requirements are very different from those of commercial/ industrial applications
- We have started a program here at Berkeley/Stanford/MIT/LBL in order to design optimal magnets for axion searches across low mass region
    - Starting with the DM Radio 50 L toroidal magnet design





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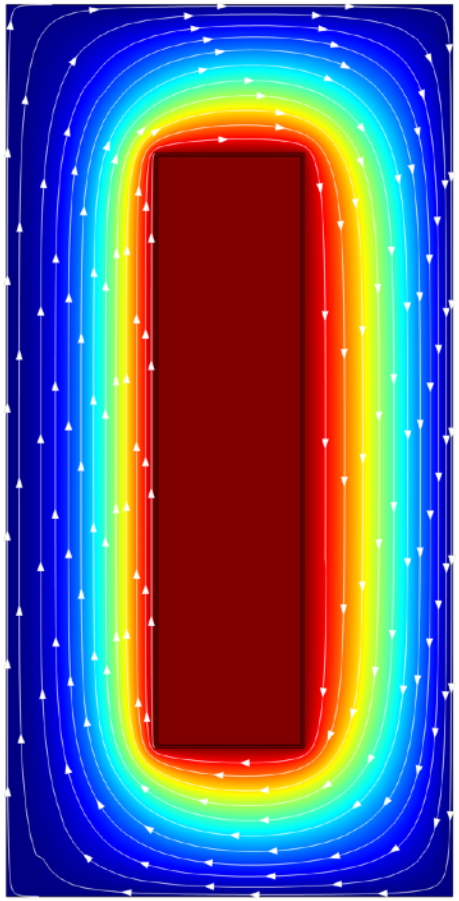
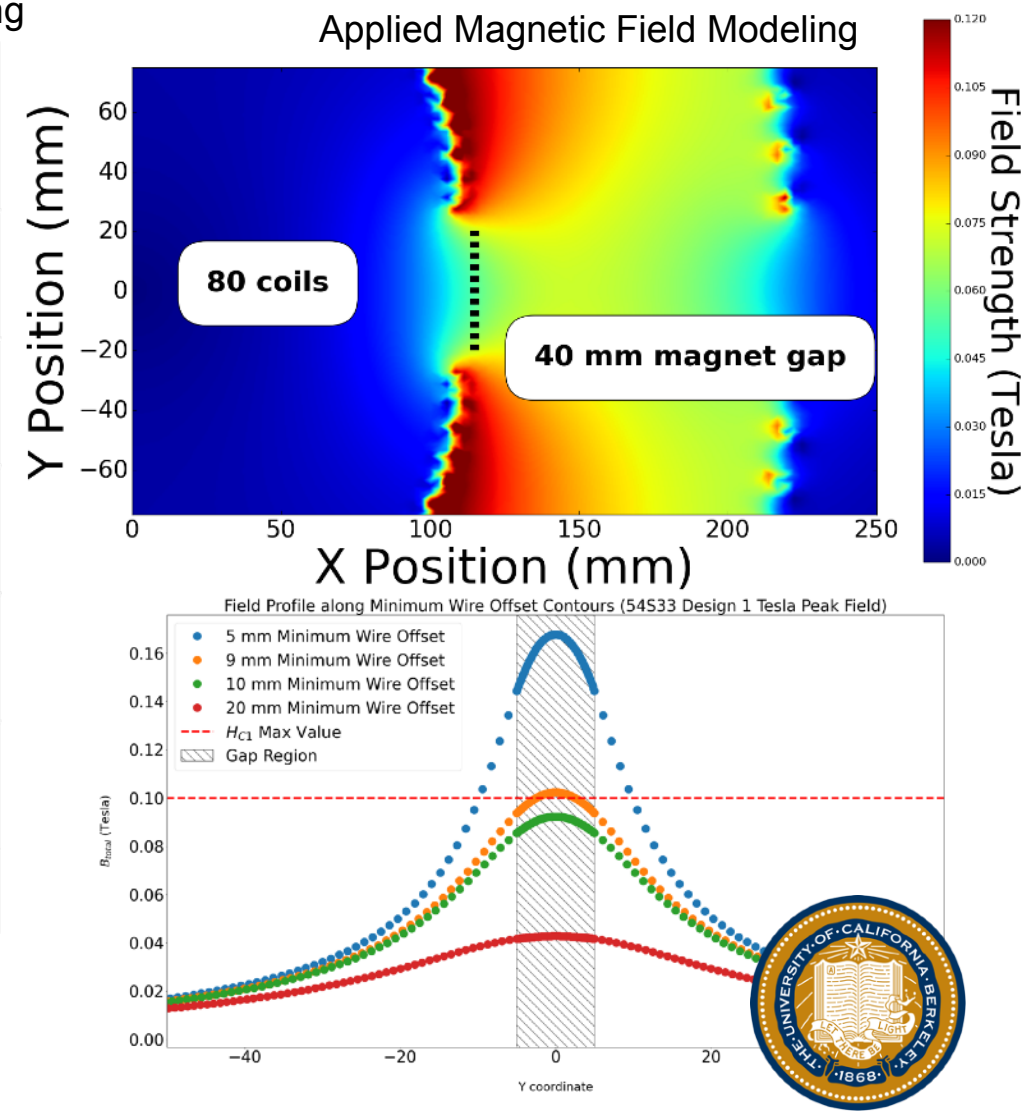
Magnetic Field Modeling

- We are modeling fields outside of the typical regions in solenoids/toroid - simulation of non-typical field profiles
- Fields need to be maximized in science region and minimized near superconducting elements
- Evaluation of the individual lumped elements in our resonator design
  - Calculation of individual inductances/capacitances for a given cross section/design

Axion Induced Field Modeling



Applied Magnetic Field Modeling



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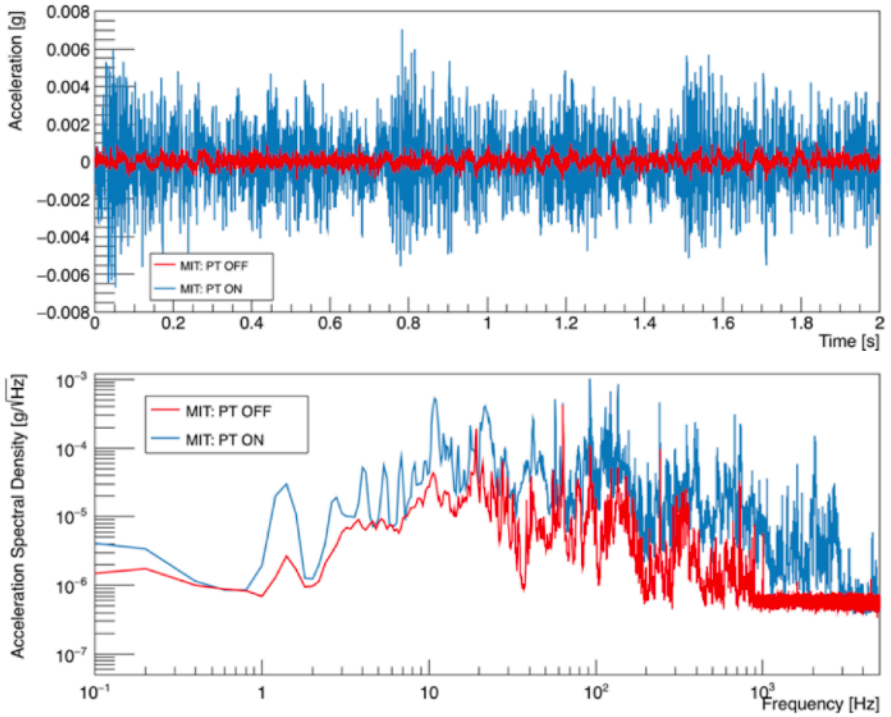
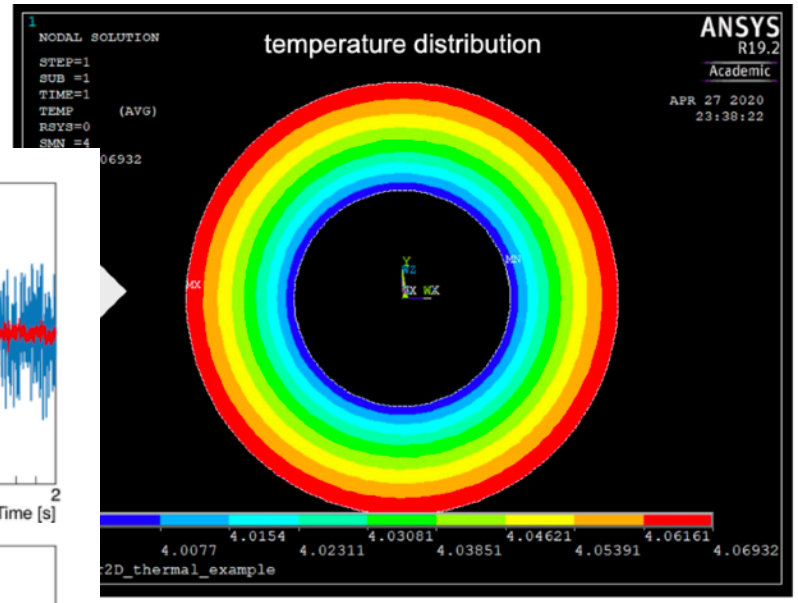
Practical Considerations

- At the same time we need to design an experiment that can actually function in a cryogenic environment
  - Thermal modeling
  - Vibration isolation
  - EMI mitigation
- These requirements will only become more pressing as experiments grow in volume and field strength
- Many of these considerations will require additional studies in the lab for verification

Vibration measurements





Temperature simulations

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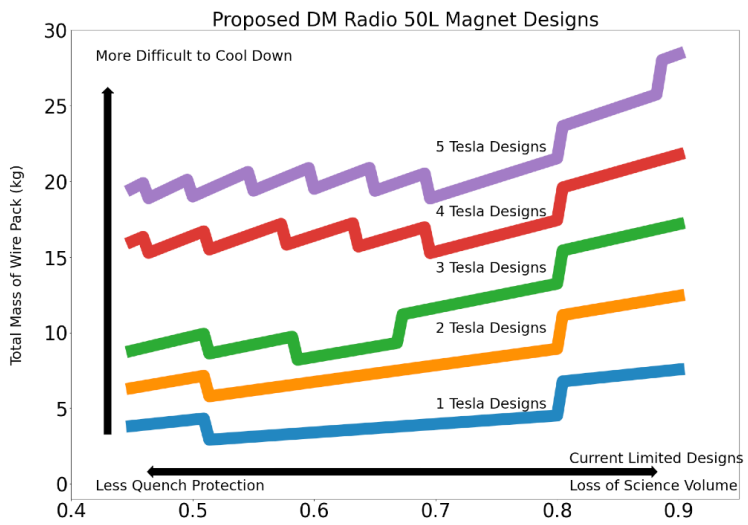
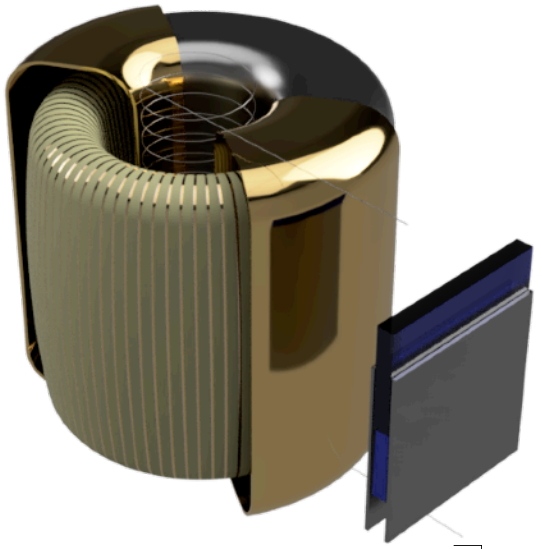
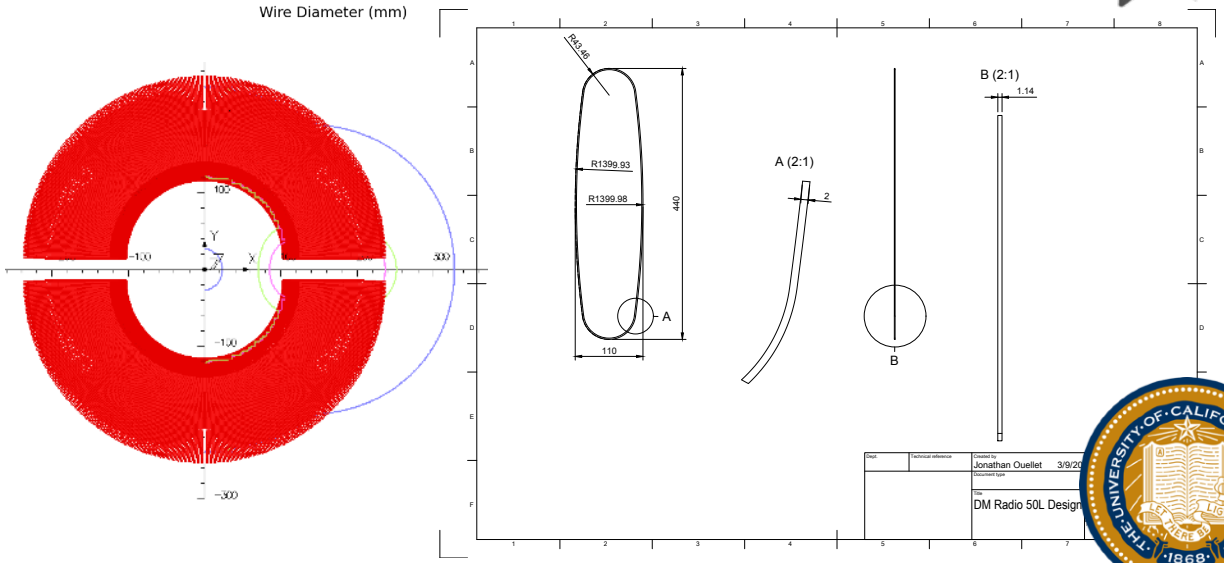
Current Projects and Conclusion

- We are currently embarking on the process of building from the ground up the magnet for DM Radio 50 L experiment, optimizing for axion sensitivity while remaining feasible
- We seek to explore design parameter space
- Lessons learned from the DM Radio 50 L design process can be applied to any axion experiment that utilizes magnetic fields
- We want to open the door to custom magnetic field profiles and magnet designs tailored to the specifics of every experiment







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End of Summary - Thank you. Questions/Comments?

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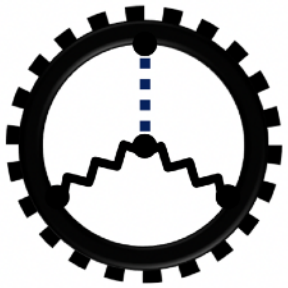

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