Yale University

Design of a Square Helmholtz Coil System for RAY

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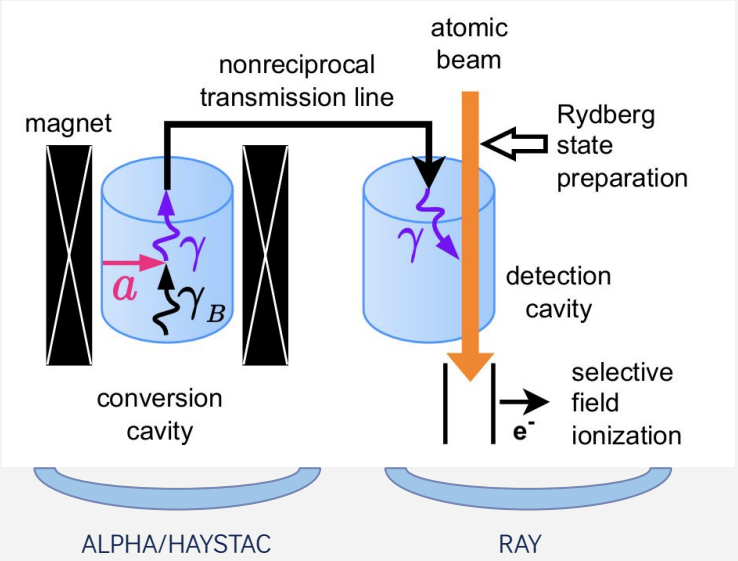
Supervised by Reina Maruyama
2026 Summer Student Research Symposium

01.

What is the RAY Experiment?

Rydberg Atoms at Yale (RAY)

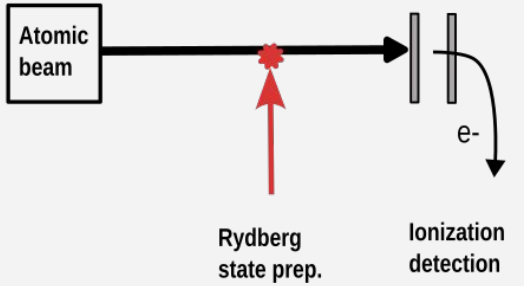
- **Axion search**
- Solves the existence of **dark matter** and the **strong charge parity** (CP) problem
- **RAY, ALPHA & HAYSTAC** → haloscope
- Problems with haloscope:
  - Lower signal
  - Increased quantum noise



Adapted from Graham et al. "Rydberg-atom-based single photon detection for haloscope axion searches." arXiv preprint arXiv: 2310.15352 (2023)

RAY (continued)

- RAY uses a **single photon detector**
- A **405nm** laser and a **975 nm** are used to excite an alkali atom
- **Rydberg atom**
  - An atom with a high principal quantum number
- Use a **Channel Electron Multiplier** (CEM) to count the number of electrons



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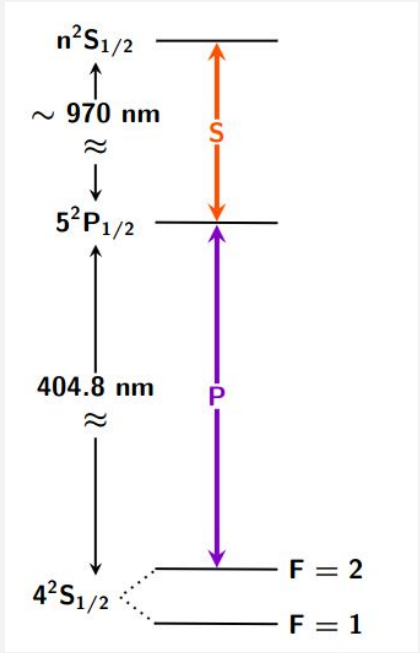
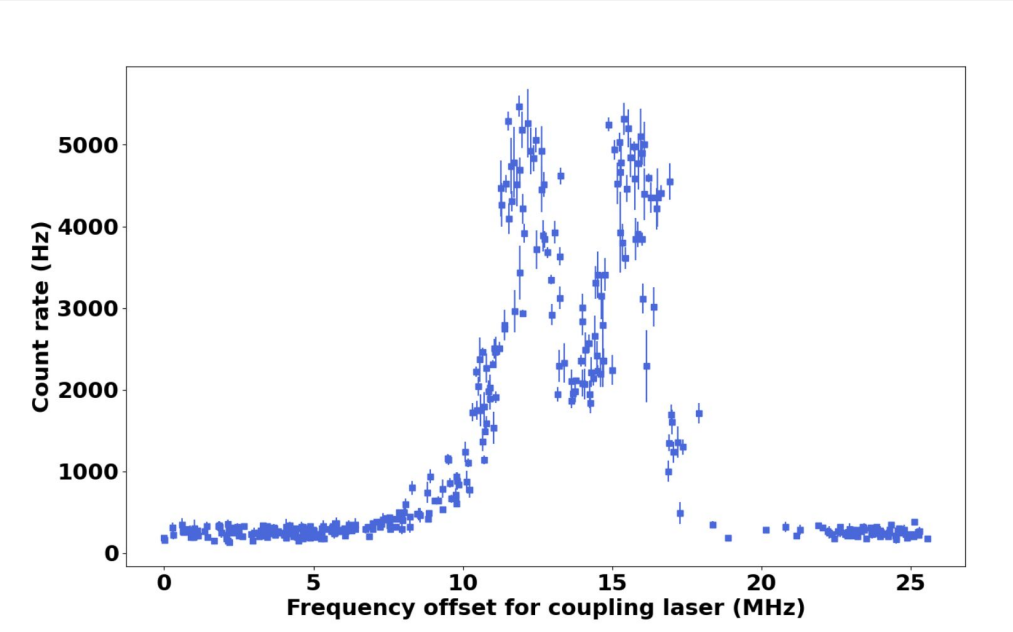


02.

Why Helmholtz coils?

Splitting of Sub States



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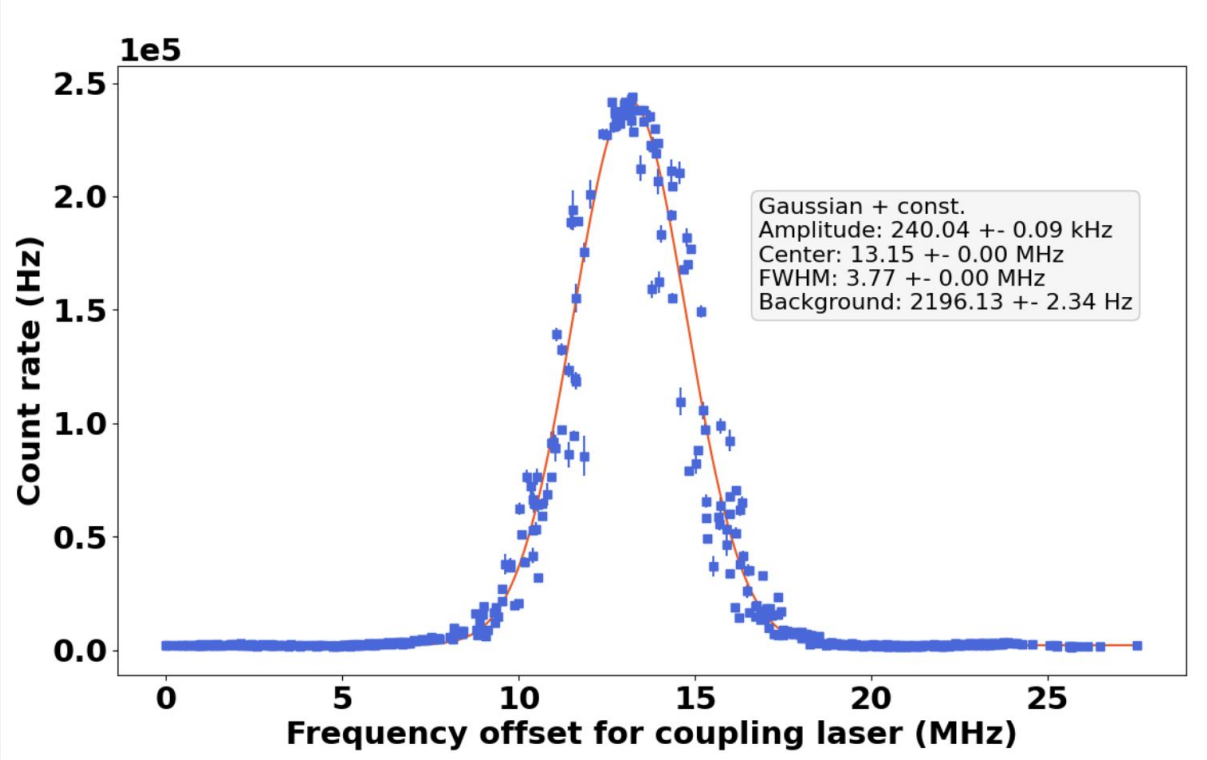
Without AIM Gauge Magnet



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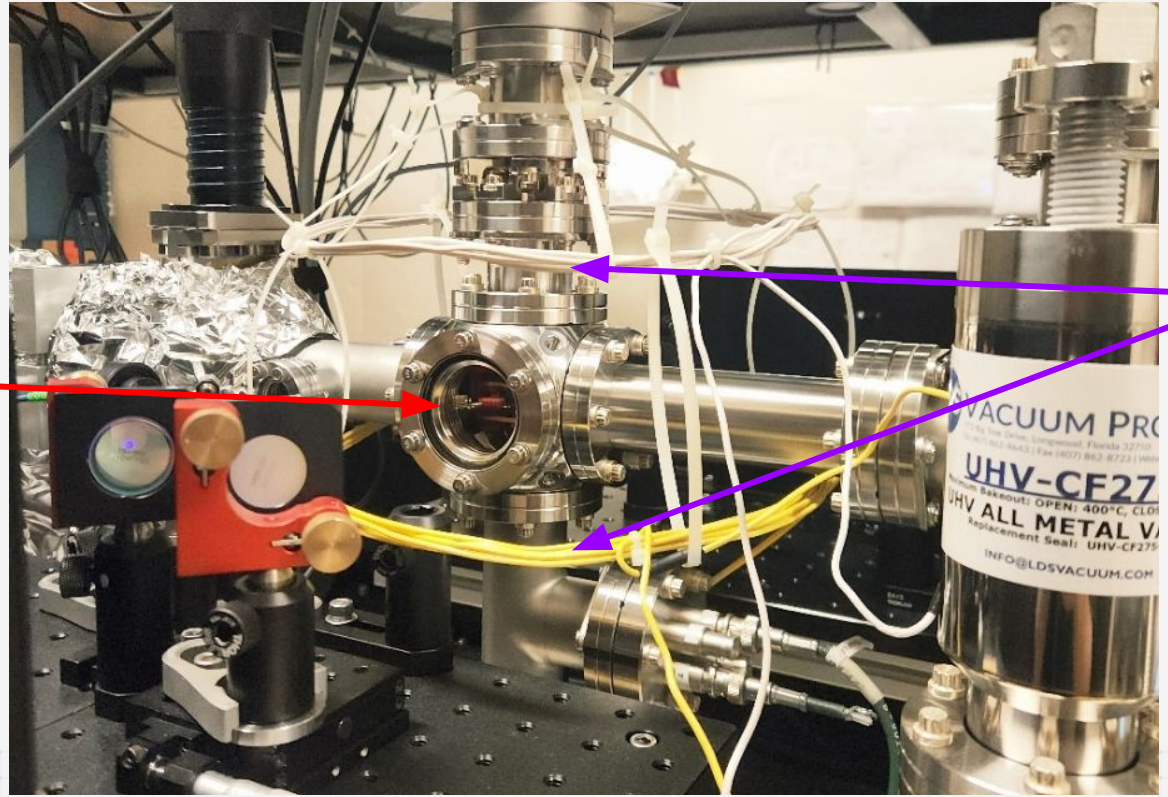
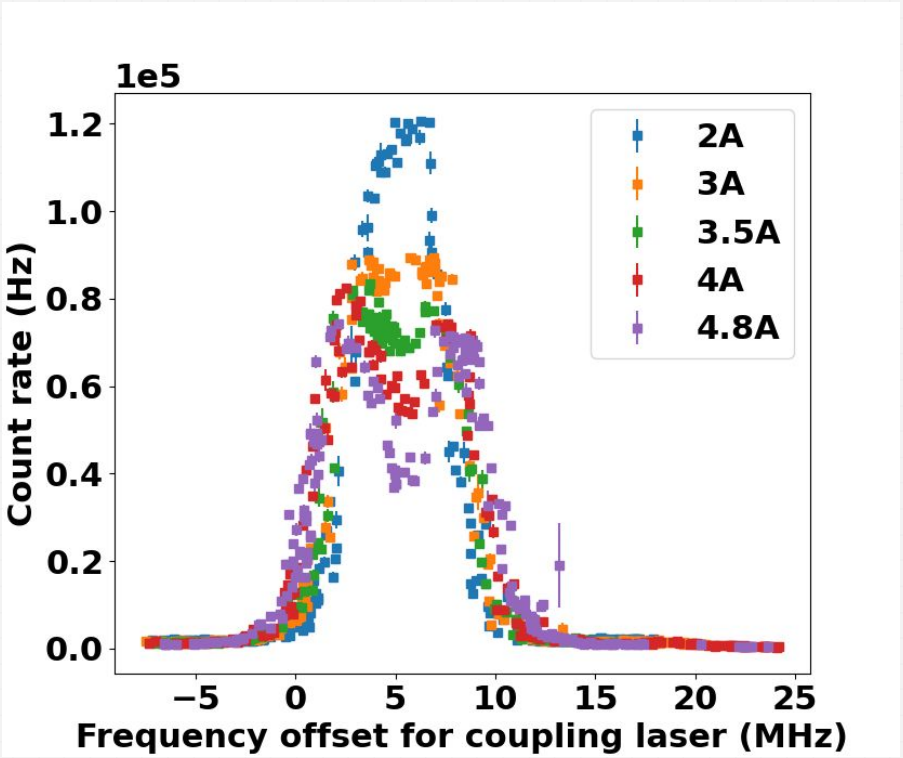
Prototype

Selective Field Ionization Chamber





Prototype Results

Magnetic field did cause splitting of the Rydberg sub-states

Inducing a Magnetic Field

1. Cancel out the Earth's magnetic field
2. Induce a controlled magnetic field

$B = 1.2969(\mu_0 NI / L)$

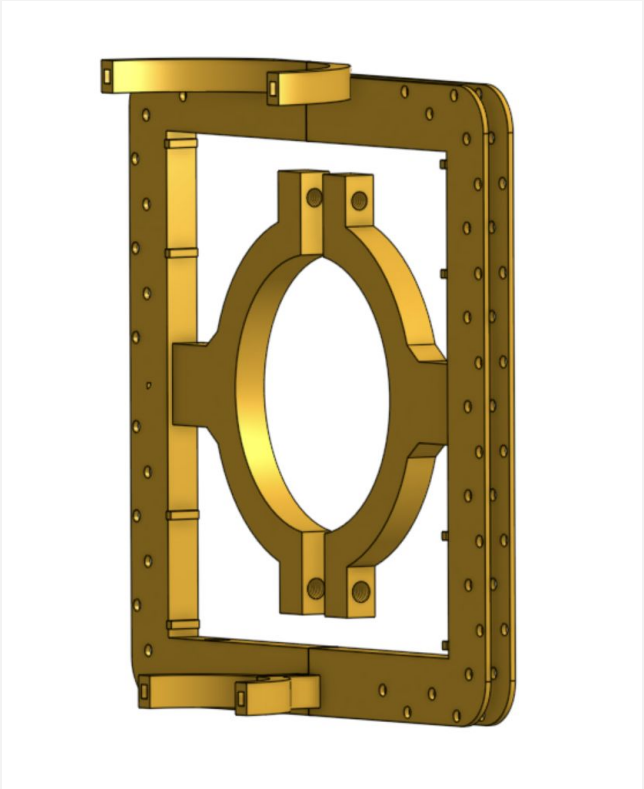
We aimed for **20-30 Gauss** and a maximum current of **15 Amps**

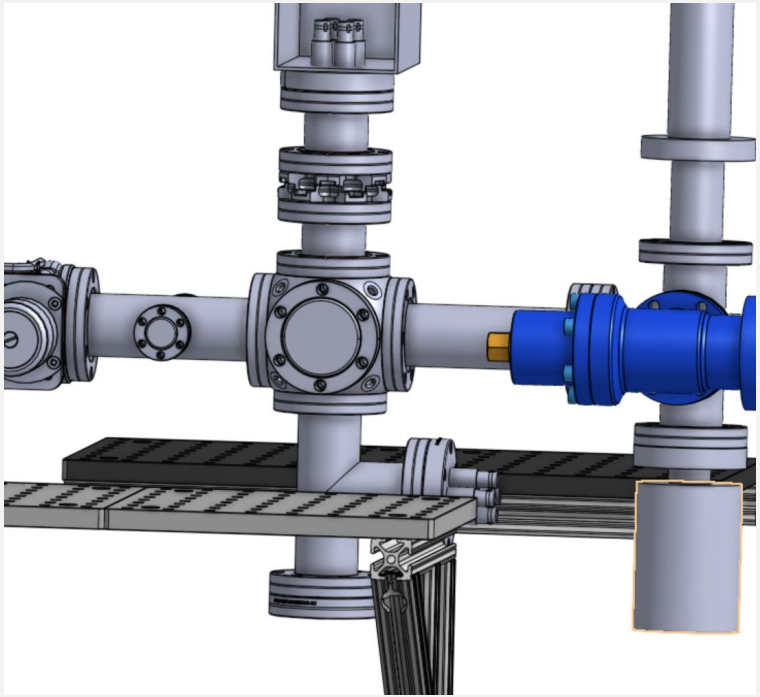
03.

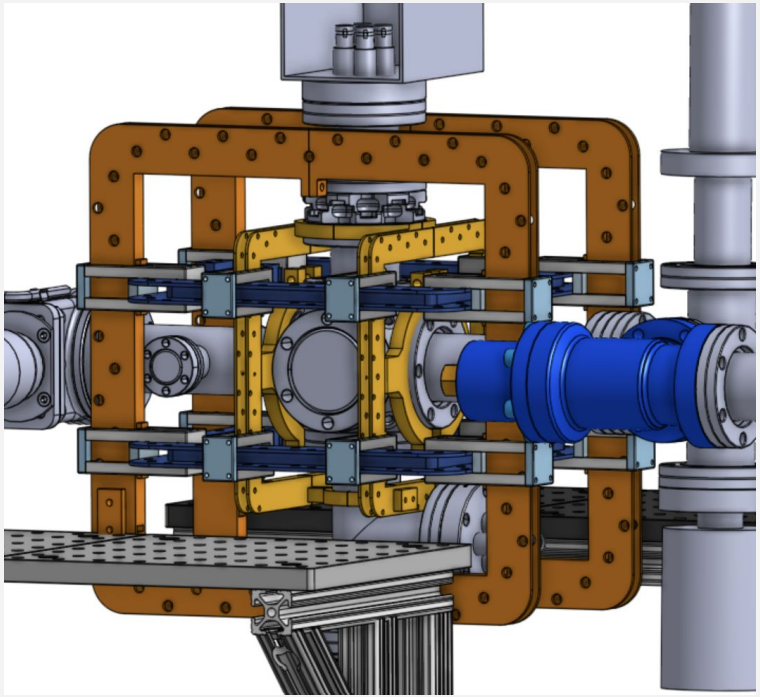
Designing the coils

3-Axis Helmholtz Coil

- Limited Space
- 3D printed frames
- Holes for the heat dissipation
- Clamp design for less vibration
- Leads for the coils
- Rectangular shape







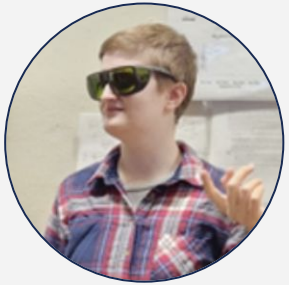
Acknowledgements

Reina Maruyama

Principal Investigator

Charles Brown

Principal investigator



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Yale Summer Experience Award

Thank You!