



Yale University

Design of a Square Helmholtz Coil System for RAY

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Supervised by Reina Maruyama

2026 Summer Student Research Symposium

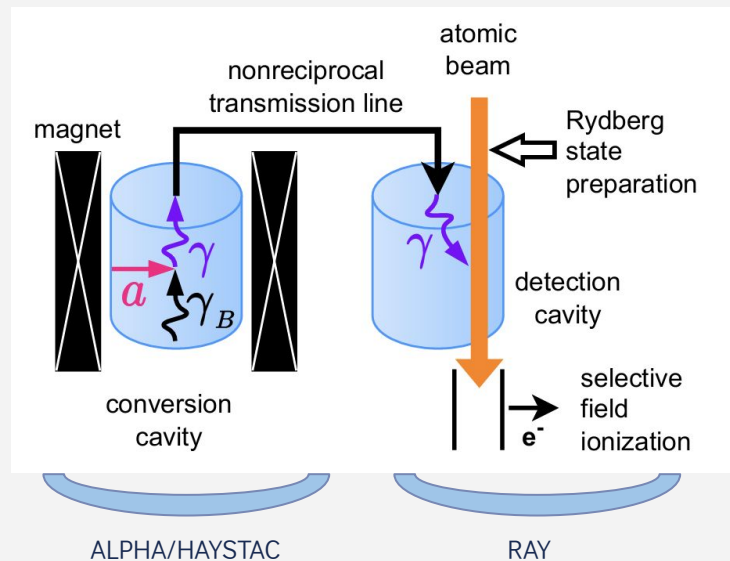
The slide features a light blue background with a fine grid pattern. In the corners, there are decorative elements consisting of blue gears of various sizes. Some gears are solid blue, while others are white with blue outlines. The gears are arranged in a way that suggests a mechanical or interconnected theme.

01.

What is the RAY Experiment?

Rydberg Atoms at Yale (RAY)

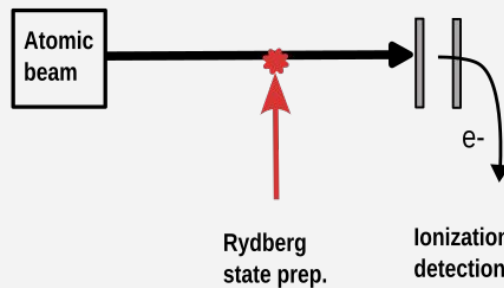
- Axion search
- Solves the existence of **dark matter** and the **strong charge parity** (CP) problem
- RAY, ALPHA & HAYSTAC → haloscope
- Problems with haloscope:
 - Lower signal
 - Increased quantum noise



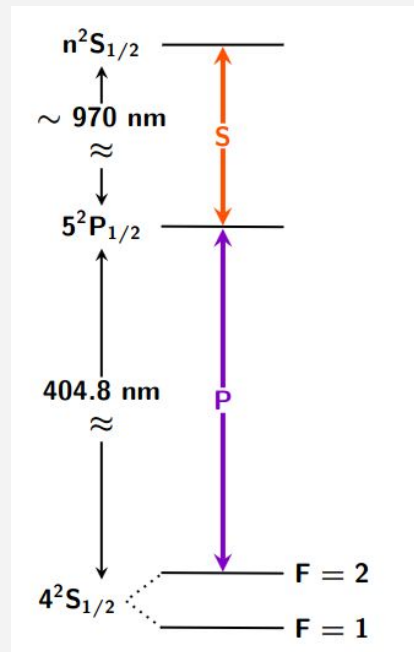
Adapted from Graham et al. "Rydberg-atom-based single photon detection for haloscope axion searches." arXiv preprint arXiv: 2310.15352 (2023)

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



Eleanor Graham

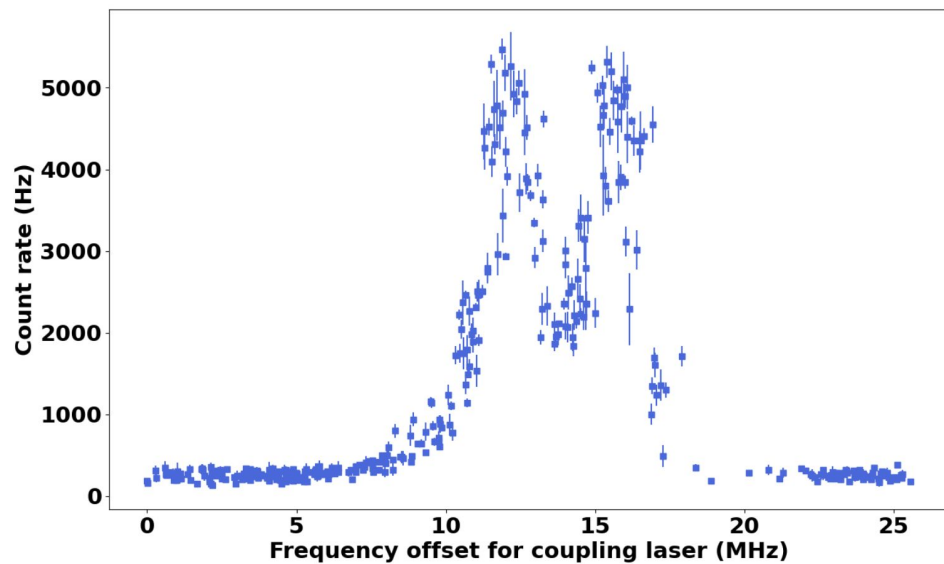


The slide features a light blue background with a fine grid pattern. In the corners, there are decorative gear icons: a large solid blue gear in the top-left, a small solid blue gear in the top-right, and several outlined blue gears of various sizes in the bottom-left and bottom-right. The number '02.' is displayed in a large, bold, dark blue font.

02.

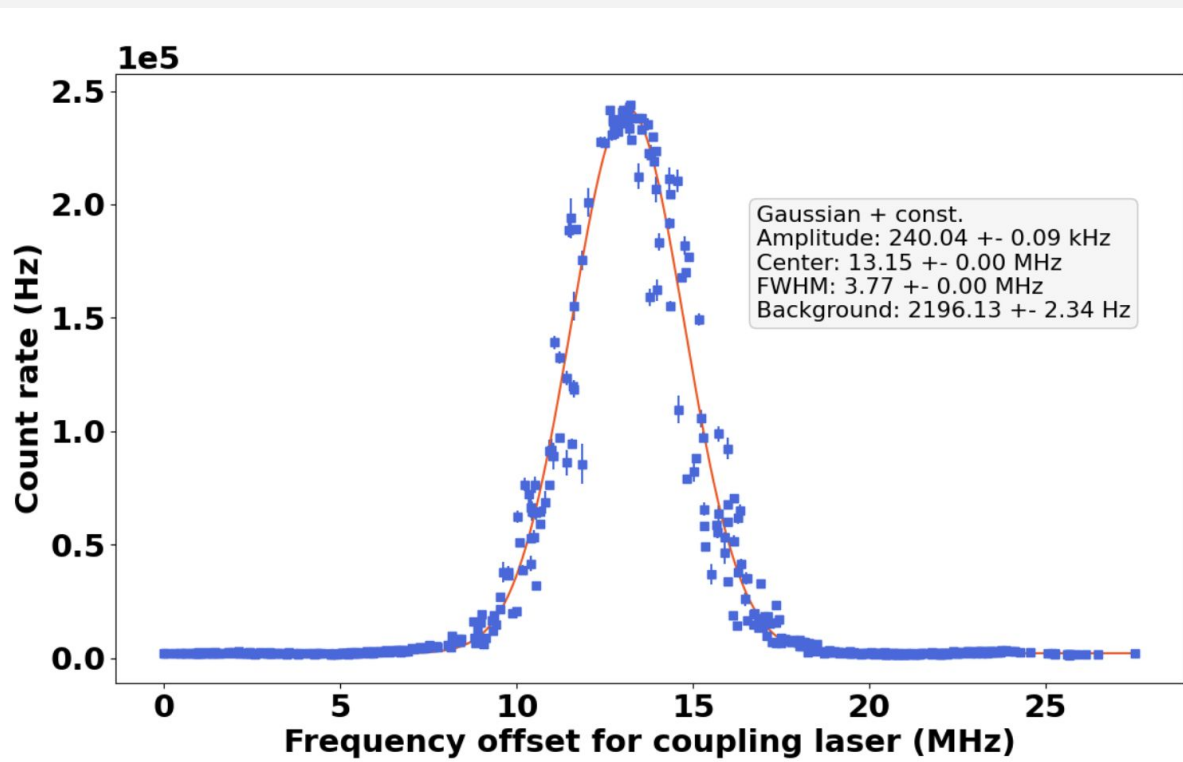
Why Helmholtz coils?

Splitting of Sub States



Eleanor Graham

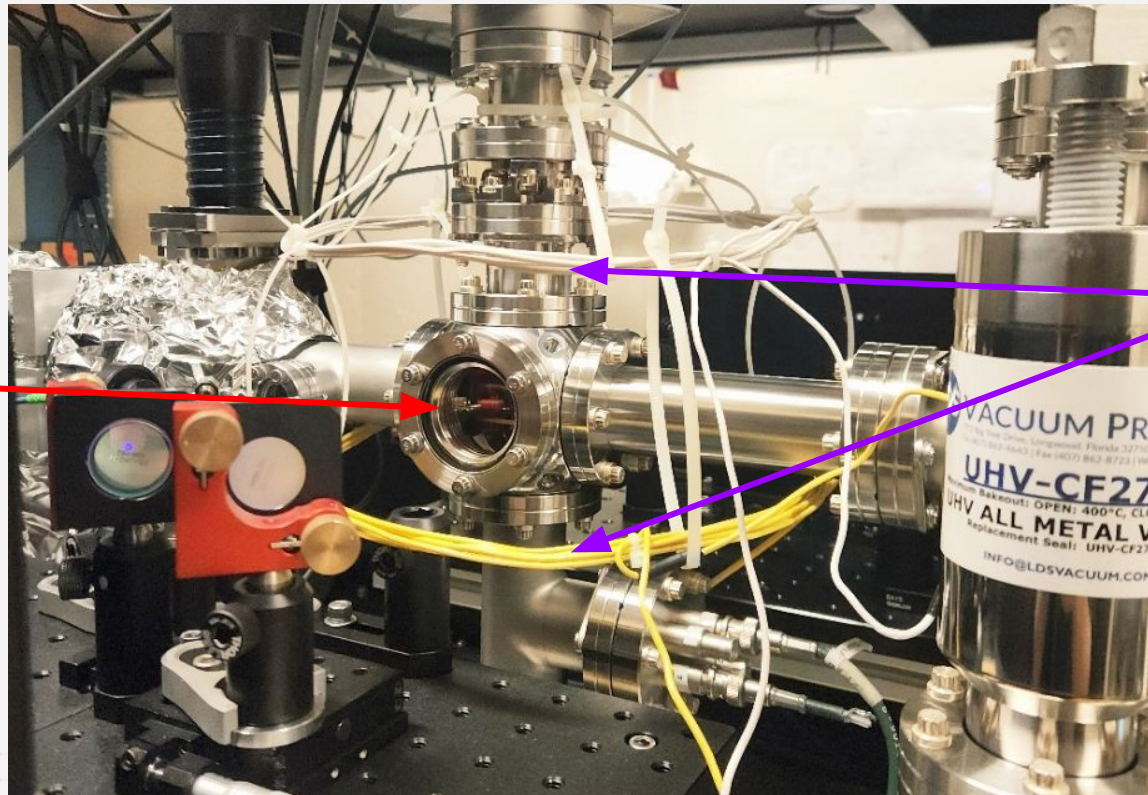
Without AIM Gauge Magnet



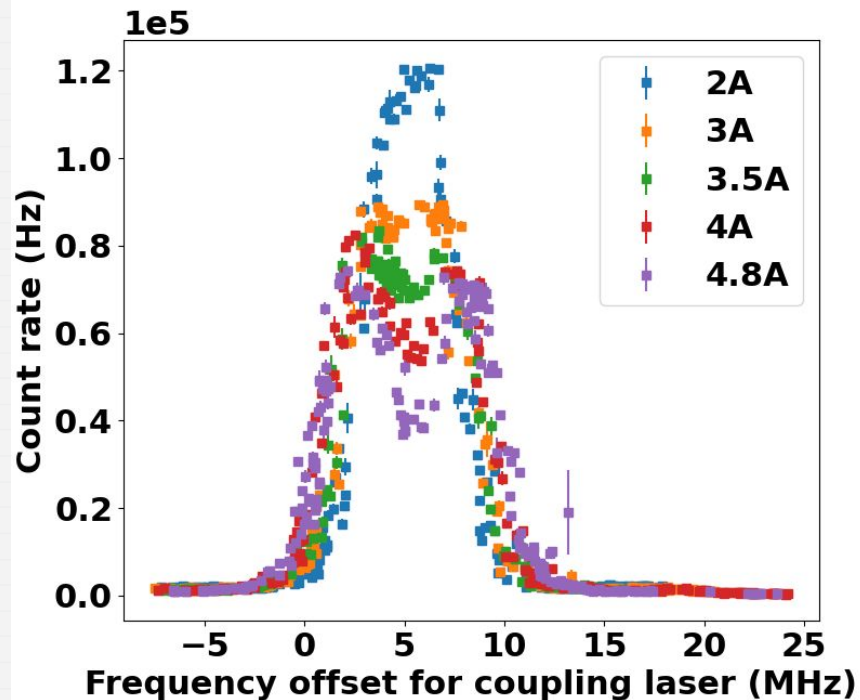
Eleanor
Graham

Prototype

Selective
Field
Ionization
Chamber



Coils



Prototype Results

Magnetic field did cause
splitting of the Rydberg
sub-states

Eleanor Graham



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**

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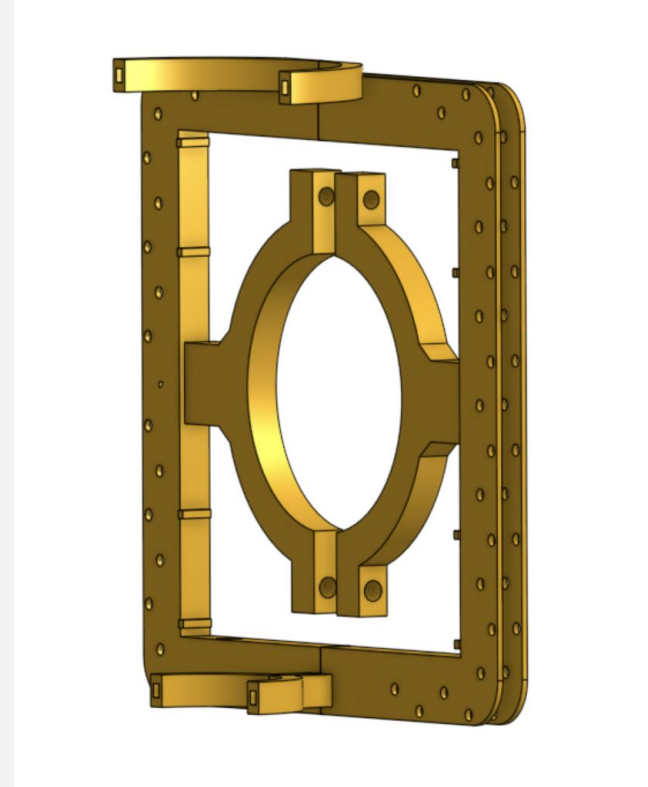
03.

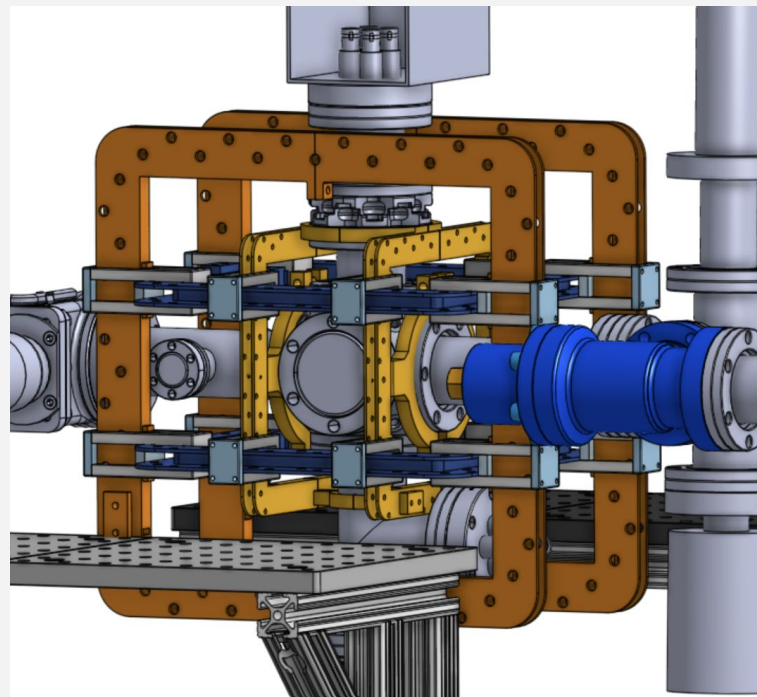
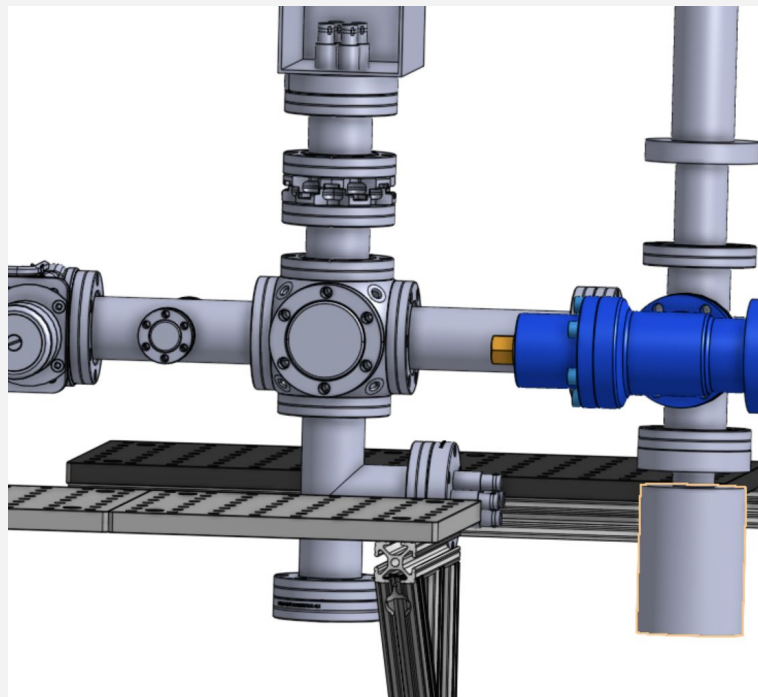
Designing the coils



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



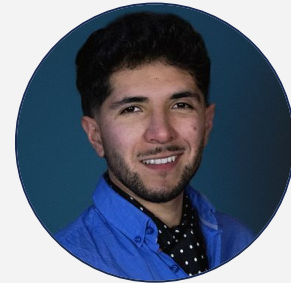
Charles Brown

Principal investigator



Eleanor
Graham

PhD Candidate



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Castro Muñoz

Graduate Student

Yale Summer Experience Award



Thank You!
