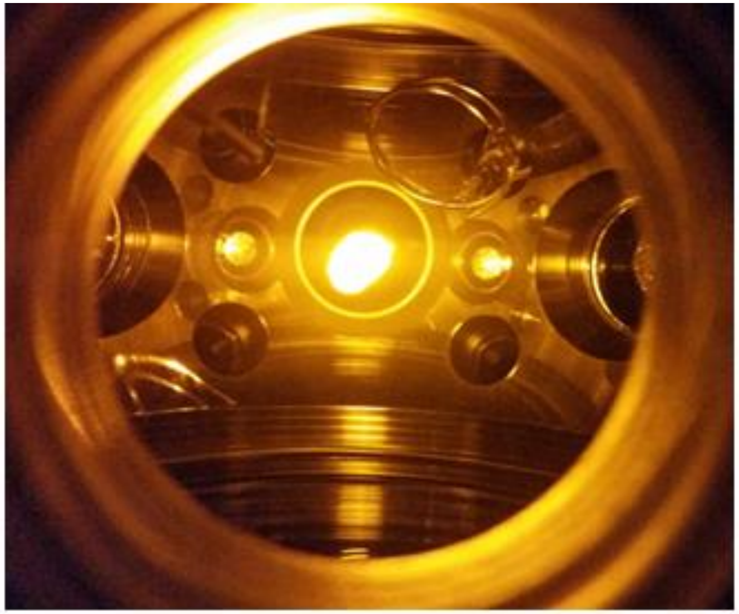
Magnetic Field Stabilization in a BEC



Cameron Cinnamon

REU Project

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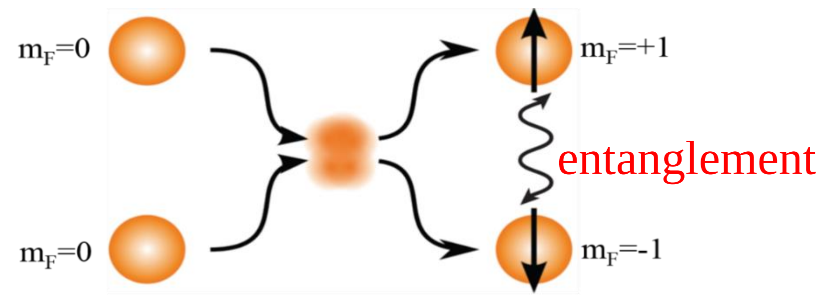
Introduction

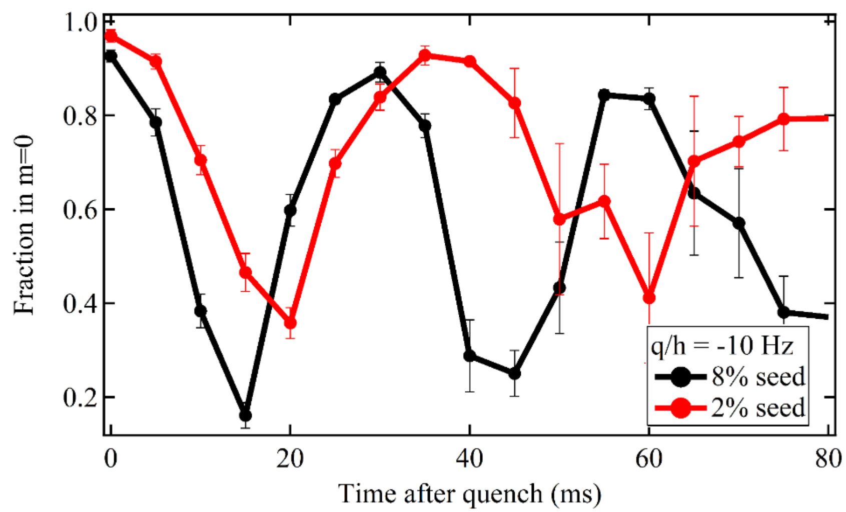
-AMO

- Ultra cold sodium gas
- Laser cooling and trapping
- Form BEC at T≈100nK
- Spin exchange collisions create **entanglement**



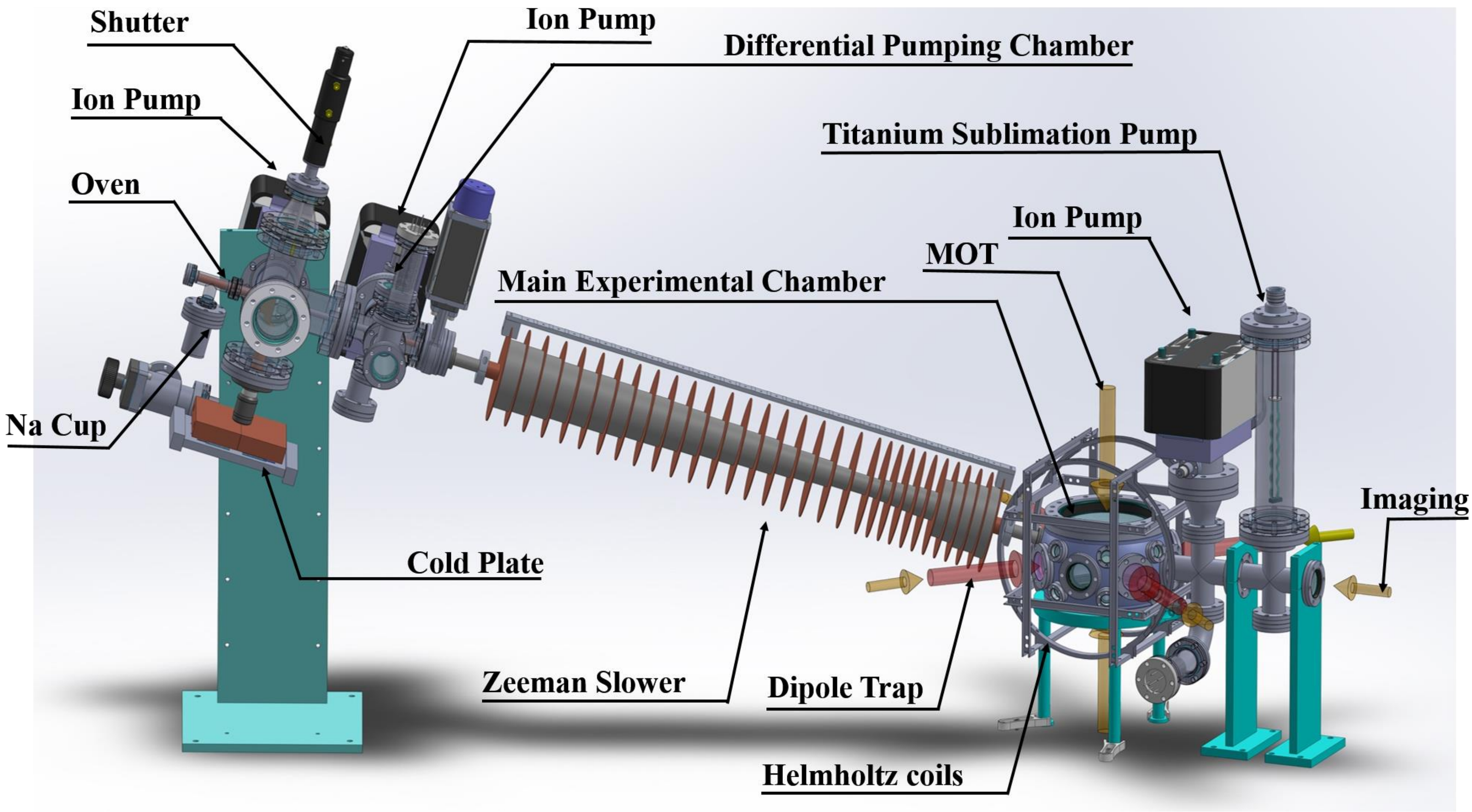
$$|m_F=0\rangle + |m_F=0\rangle \rightarrow |m_F=+1\rangle + |m_F=-1\rangle$$

- These collisions are very sensitive to magnetic fields.
- My project is to stabilize B-Field to reduce these error bars.



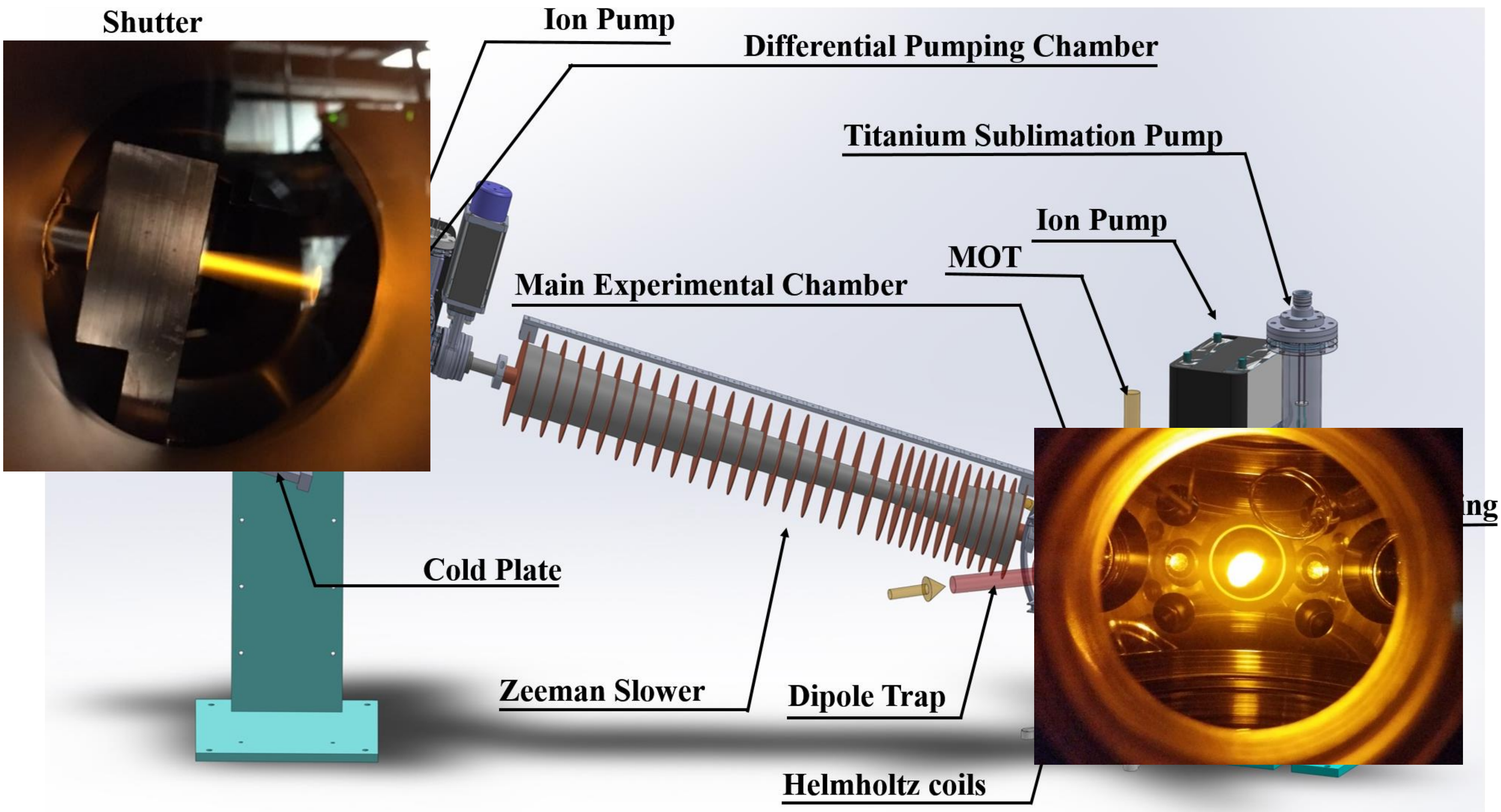
Spinor BEC Setup

-AMO



- Hot atomic gas is created in an oven, slowed in the Zeeman slower tube, and then trapped and cooled in the main chamber.

Spinor BEC Setup



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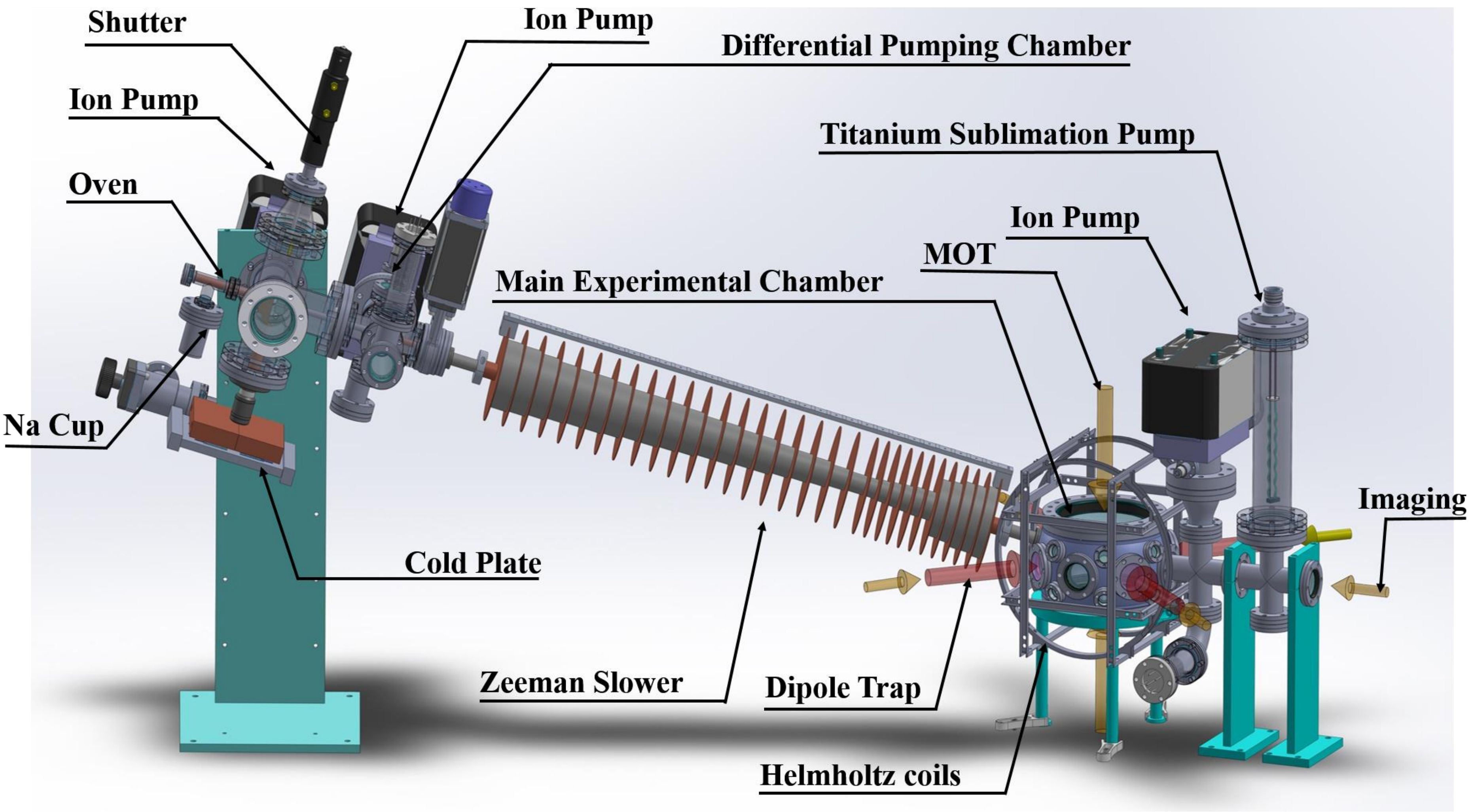
Spinor BEC Setup



- Hot atomic gas is created in an oven, slowed in the Zeeman slower tube, and then trapped and cooled in the main chamber.

Magnetic Field Stabilization

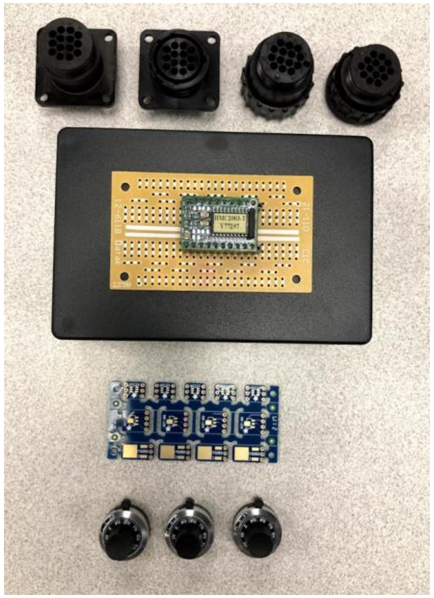
-AMO

- Need to compensate for external B-Field fluctuations. (opening drawers, moving chairs, moving elevator, etc)
- My project is to finish the implementation of a B-Field sensor.
- The sensor will detect very small (~40μG) fluctuations in the magnetic field surrounding the vacuum chamber.
- This information will be sent to the current controller for the Helmholtz coils.
- The motivation for this project is to reduce error bars in BEC experiments.

Current Status

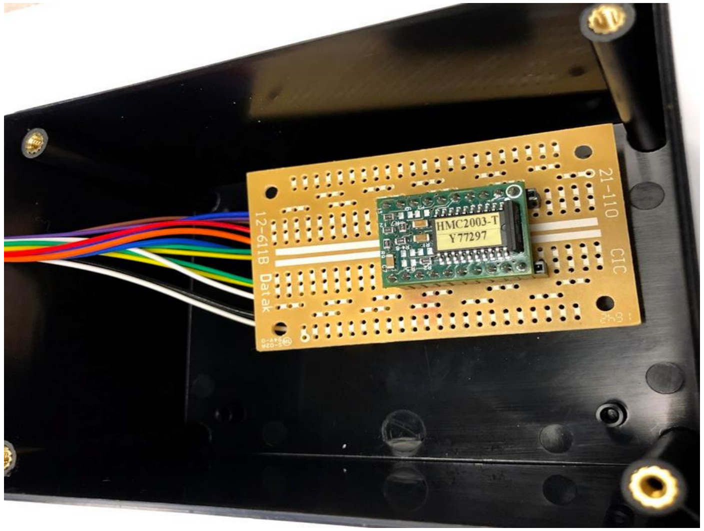
I have already:

- Ordered and received parts to build the sensor module and control box circuitry.
- Begun assembly of the sensor module and the cable connection for it.



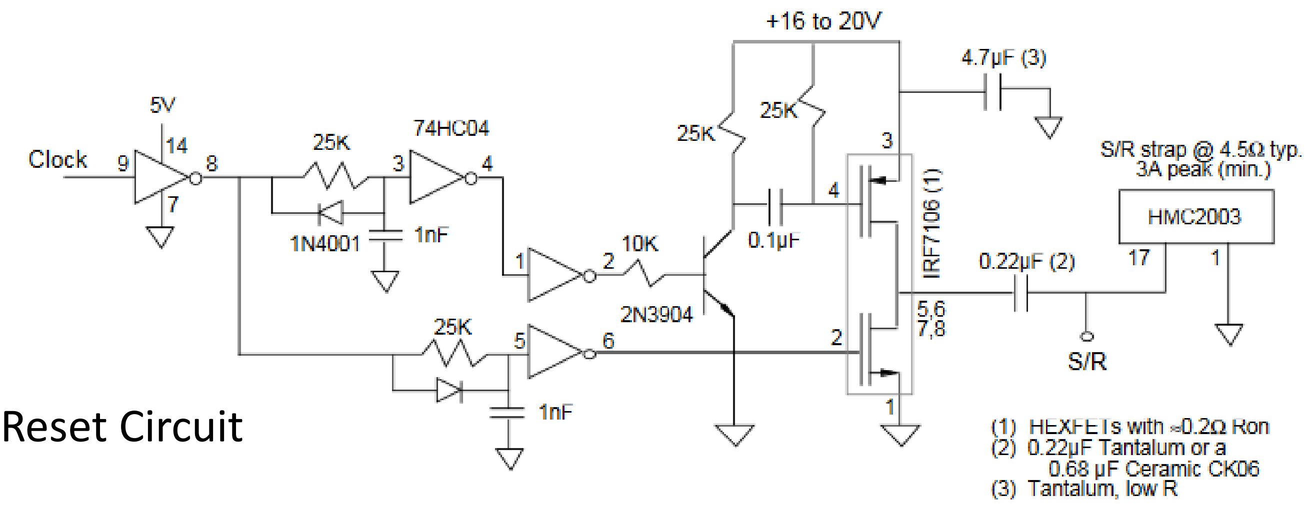
I am in the process of:

- Testing circuits.
- Designing the control box.



Looking Ahead

- Thoroughly test all circuits.
- Design the front panel with connection ports for the control box.
- Select or manufacture an enclosure for these controls.
- Test the sensor module and control box together as a package.
- Design an experiment to measure the difference that this sensor and feedback loop make in the BEC experiments.



Sensor Set/Reset Circuit

Conclusion

- The BEC experiments rely on a precise magnetic field.
- I have enclosed the magnetic field sensor.
- I am in the build and testing phase for various circuits.
- Once complete, this sensor will detect changes in the B-Field at an adjustable level and relay this information to a current controller for the Helmholtz coils.

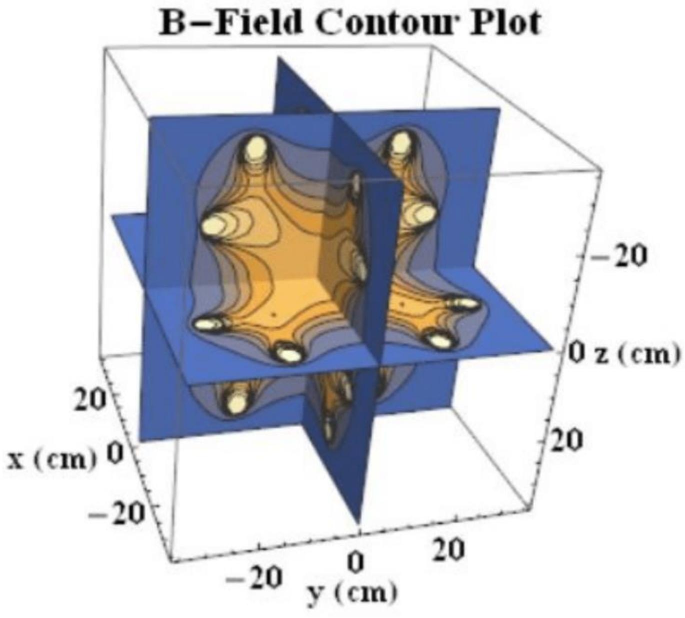


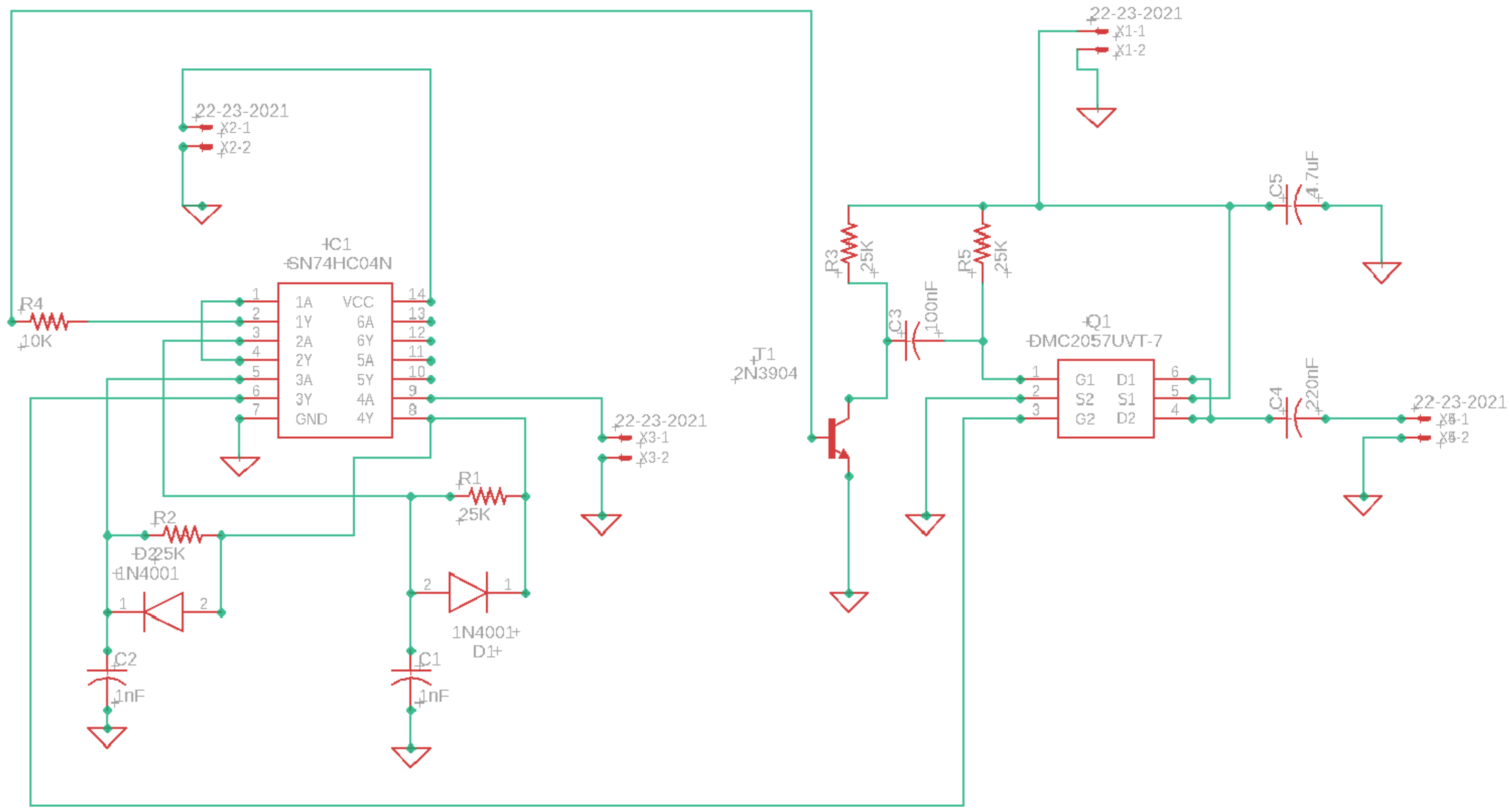
Photo from Justin Kittell presentation.

HMC2003

SPECIFICATIONS

Characteristics	Conditions	Min	Typ	Max	Units
Magnetic Field					
Sensitivity		0.98	1	1.02	V/gauss
Null Field Output		2.3	2.5	2.7	V
Resolution			40		µgauss
Field Range	Maximum Magnetic Flux Density	-2		2	gauss
Output Voltage	Each Magnetometer Axis Output	0.5		4.5	
Bandwidth			1		kHz
Errors					
Linearity Error	±1 gauss Applied Field Sweep ±2 gauss Applied Field Sweep		0.5 1	2 2	%FS
Hysteresis Error	3 Sweeps across ±2 gauss		0.05	0.1	%FS
Repeatability Error	3 Sweeps across ±2 gauss		0.05	0.1	%FS
Power Supply Effect	PS Varied from 6 to 15V With ±1 gauss Applied Field Sweep			0.1	%FS
Offset Strap					
Resistance				10.5	ohms
Sensitivity		46.5	47.5	48.5	mA/gauss
Current				200	mA
Set/Reset Strap					
Resistance			4.5	6	ohms
Current	2 us pulse, 1% duty cycle	3.0	3.2	5	amps
Tempcos					
Field Sensitivity			-600		ppm/°C
Null Field	Set/Reset Not Used Set/Reset Used		±400 ±100		ppm/°C
Environments					
Temperature	Operating Storage	-40 -55	- -	+85 +125	°C °C
Shock			100		g
Vibration			2.2		g rms
Electrical					
Supply Voltage[(3)]		6		15	VDC
Supply Current				20	mA

(1) Unless otherwise stated, test conditions are as follows: Power Supply = 12VDC, Ambient Temp = 25°C, Set/Reset switching is active



22-23-2021
X2-1
X2-2
IC1
SN74HC04N
1A
1Y
2A
2Y
3A
3Y
GND
VCC
6A
6Y
5A
5Y
4A
4Y
R4
10K
R1
25K
R2
25K
D2
1N4001
D1
1N4001
C2
1nF
C1
1nF
22-23-2021
X3-1
X3-2
T1
2N3904
R3
25K
R5
25K
C3
100nF
22-23-2021
X1-1
X1-2
C5
4.7uF
Q1
DMC2057UVT-7
G1
S2
G2
D1
S1
D2
C4
220nF
22-23-2021