First Ion Mass Measurement with TAMUTRAP

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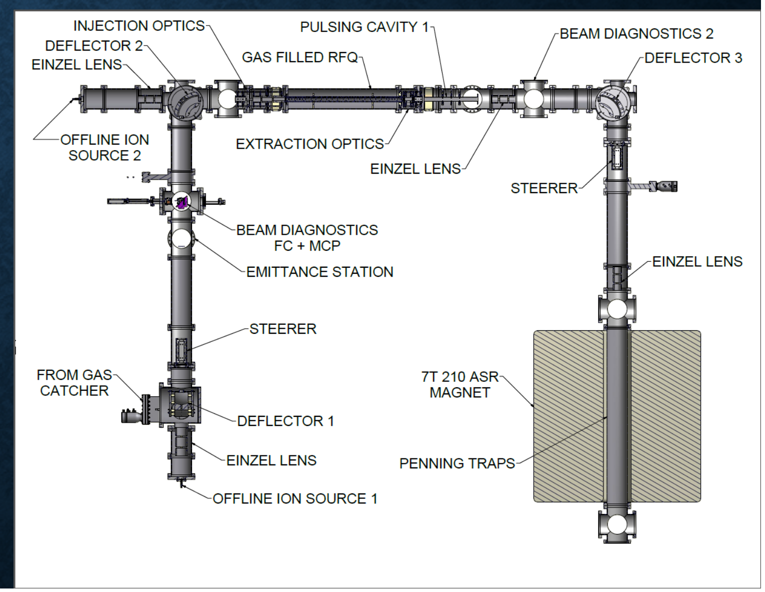
OUTLINE

- Introduction to the Penning trap
- How to trap and excite ions
- The Experiment
- Conclusion & Future work

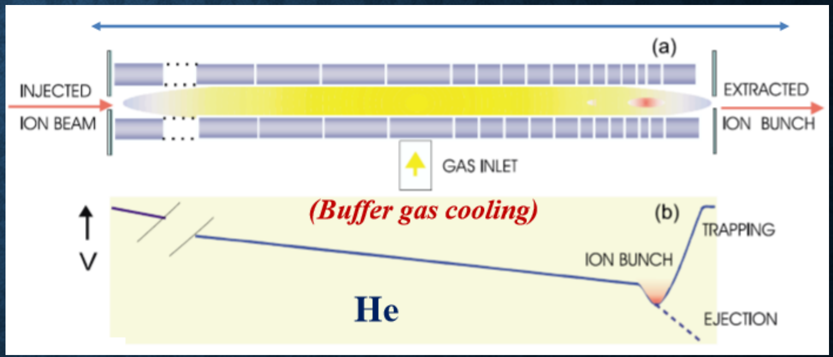
THE BEAMLINE

The beamline is a complex set of deflectors, lenses, and steerers in order to control the path the ion takes while traveling into the Penning trap.



THE RFQ
(RADIOFREQUENCY QUADRUPOLE)

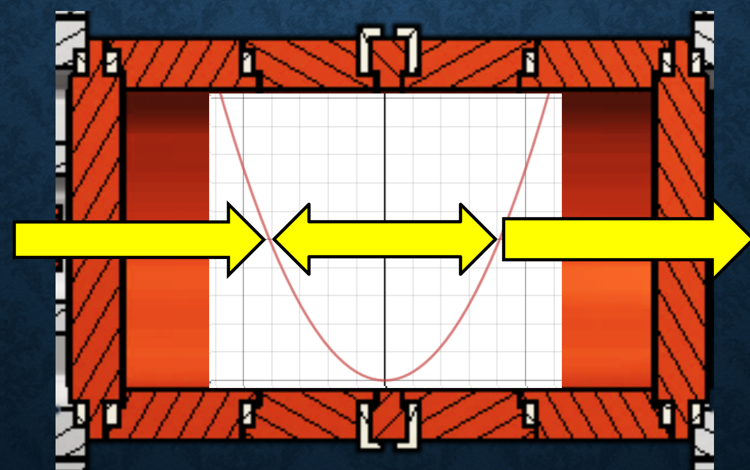
- RFQ used to obtain a consistent beamline. Same energy for ion bunch
- Ions loose their energy by collisions with He gas
- The ions accumulate at the end via a potential field then released back into the beamline



TRAPPING IONS

Penning traps will confine ions:

- axially with an electric field



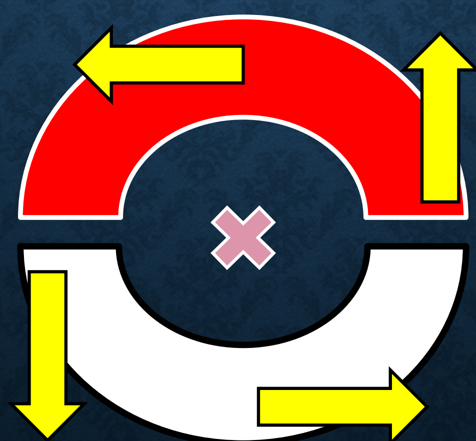
TRAPPING IONS

Penning traps will confine ions:

- axially with an electric field
- radially with a magnetic field

$$\bar{F} = q\ (\bar{v} x \bar{B})$$

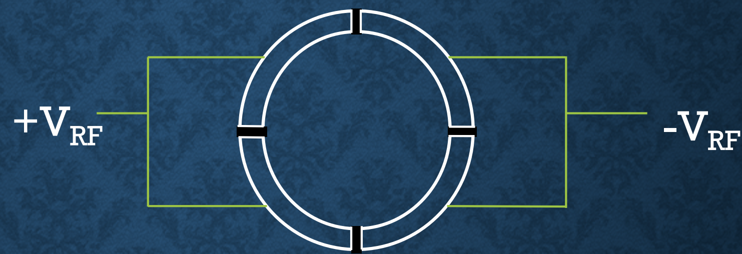
Assume $\bar{v}$ started up:

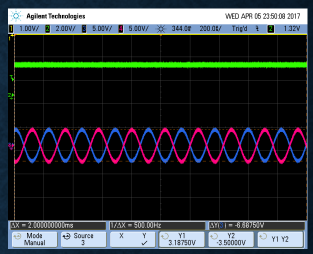


DIFFERENT EXCITATIONS

Different settings on the beamline will affect which excitation we observe. These are:

- Magnetron ω_-
- Reduced Cyclotron ω_+
- Pure Cyclotron ω_c





Cyclotron Frequency

$$\omega_- + \omega_+ = \omega_c = \frac{q}{m} * B$$

Magnetron

$$\omega_- = \frac{\omega_c}{2} - \frac{1}{2}\sqrt{\omega^2{}_c - 2\,\omega^2{}_z}$$

Reduced Cyclotron

$$\omega_+ = \frac{\omega_c}{2} + \frac{1}{2}\sqrt{\omega^2{}_c - 2\,\omega^2{}_z}$$

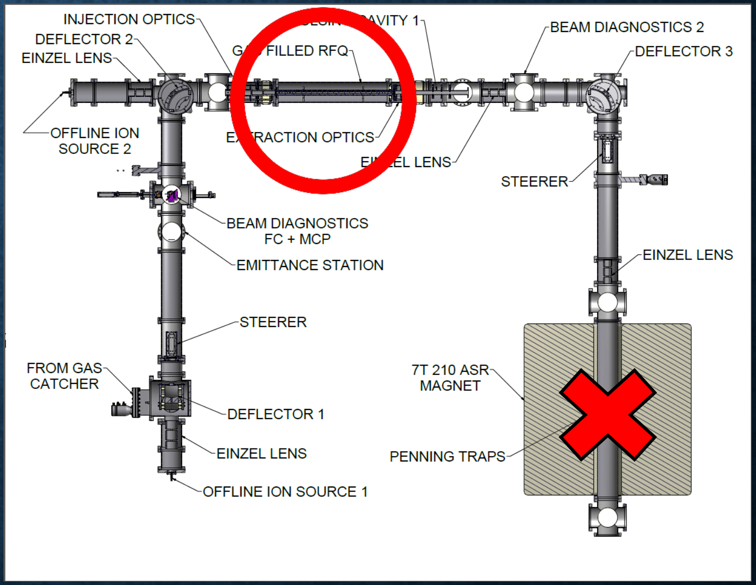
Axial Frequency

$$\omega_z = \sqrt{\frac{qU_0}{md^2}}$$

THE EXPERIMENT

TEST 1 – COOLING AND BUNCHING

- GOAL: Is the RFQ maintaining consistent energies for ions?

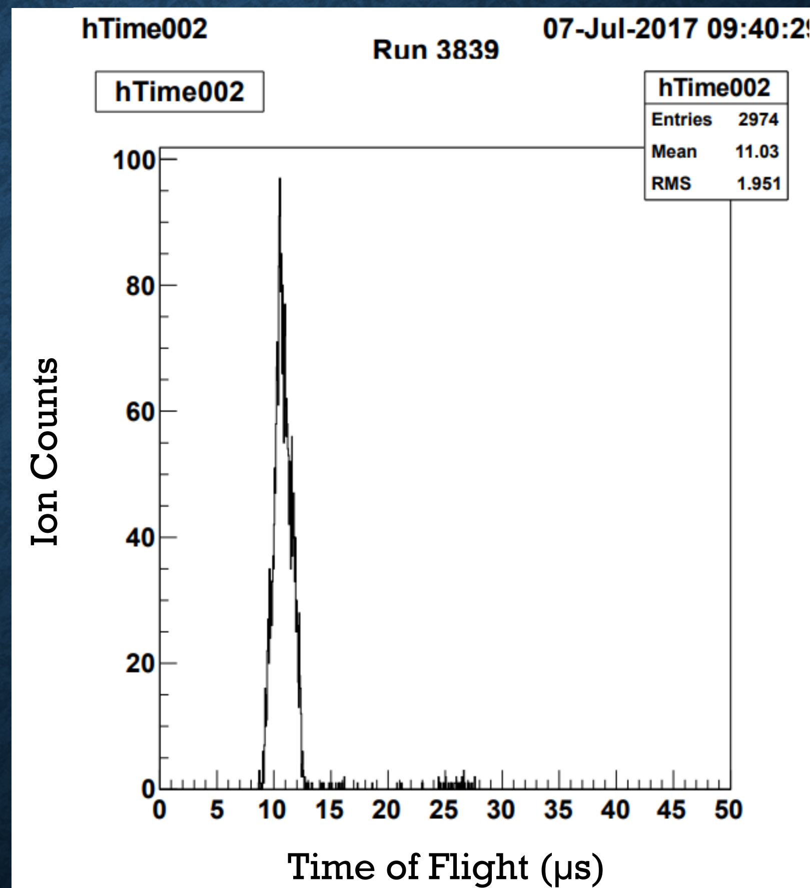


TEST 1 – COOLING AND BUNCHING

- GOAL: Is the RFQ maintaining consistent energies for ions?

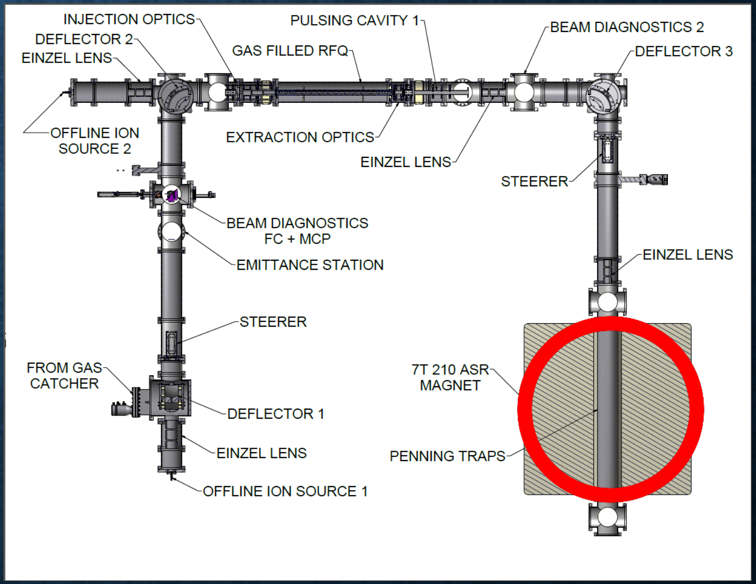
YES

Time Elapsed:
5 minutes



TEST 2 –
PENNING TRAP ONLINE (NO EXCITATION)

- GOAL: Can we see sodium being detected while trapping for 400ms?

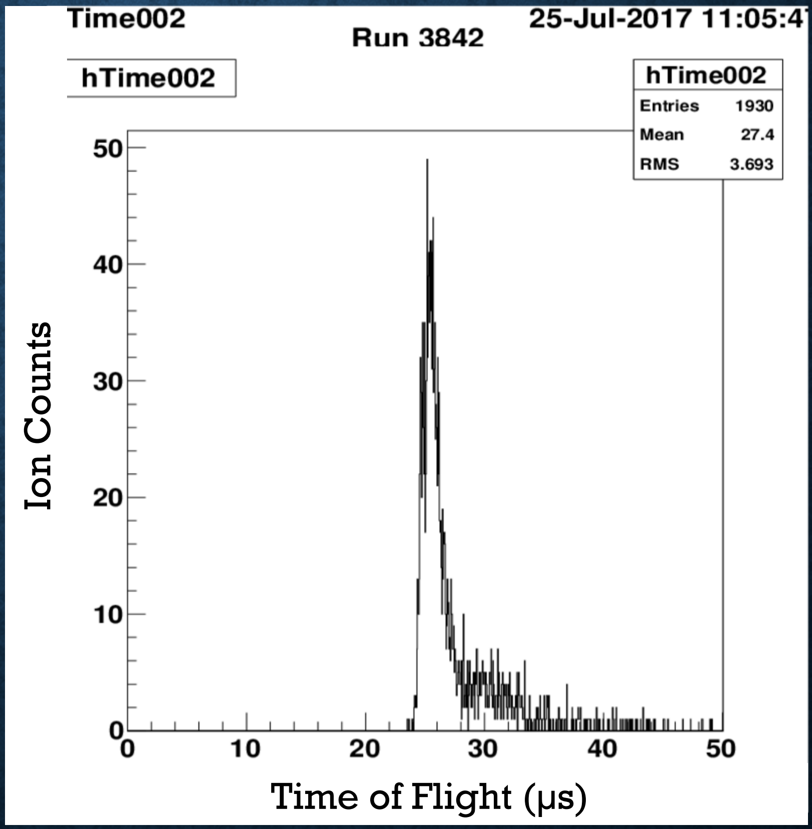


TEST 2 – PENNING TRAP ONLINE (NO EXCITATION)

- GOAL: Can we see sodium being detected while trapping for 400ms?

YES

Time Elapsed:
2 hours

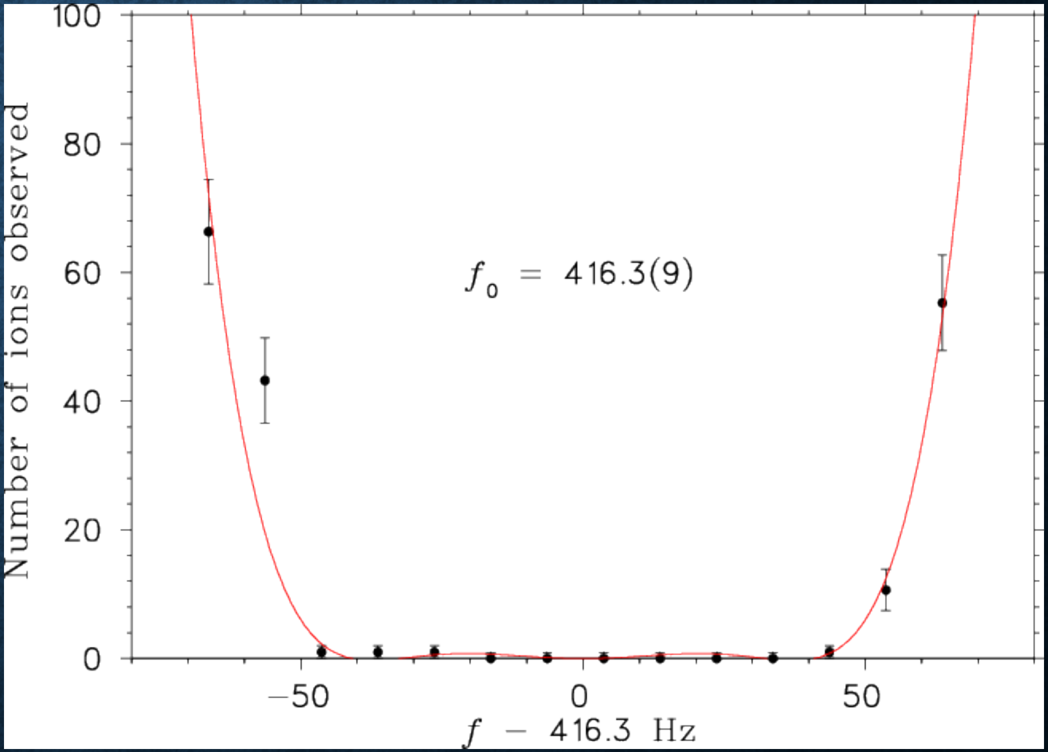


MAGNETRON EXCITATION

ω_

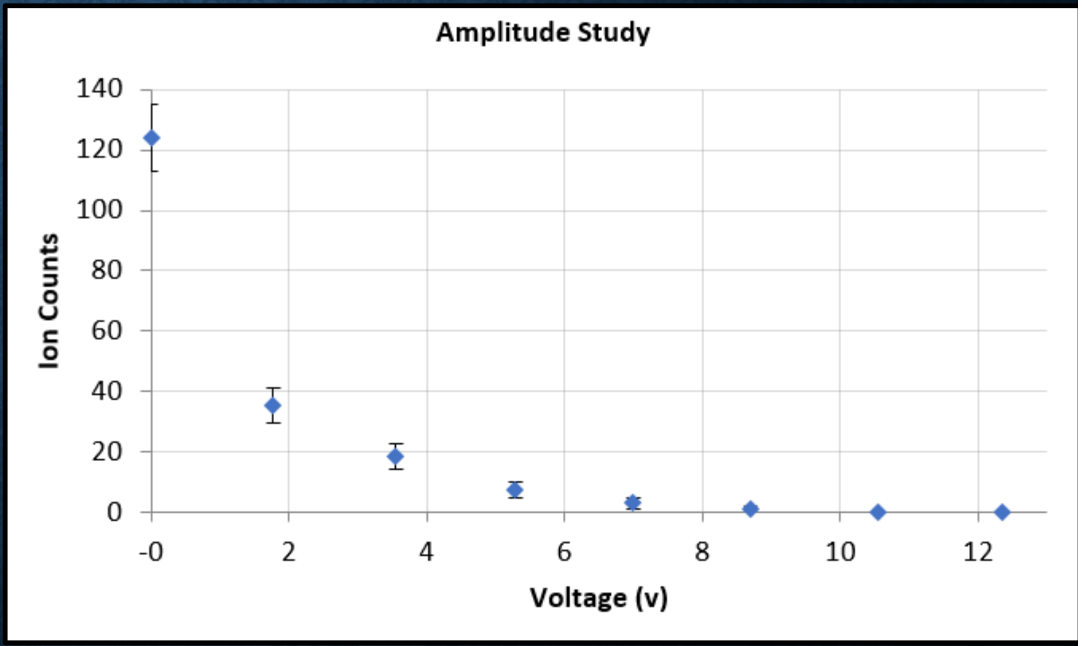
- GOAL: At which frequency do we observe the ions being excited?

  416 (9) Hz



MAGNETRON EXCITATION
ω_-

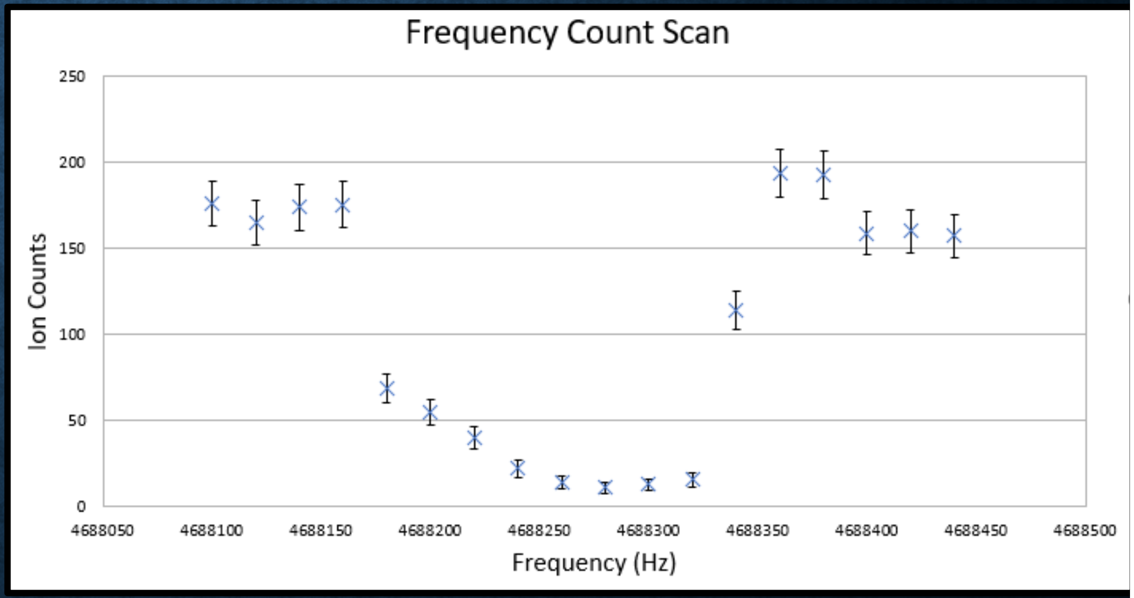
- GOAL: Checking if the voltage we are applying actually has an effect on ion excitation



REDUCED CYCLOTRON ω_+

- GOAL: At which frequency do we observe the ions being excited?

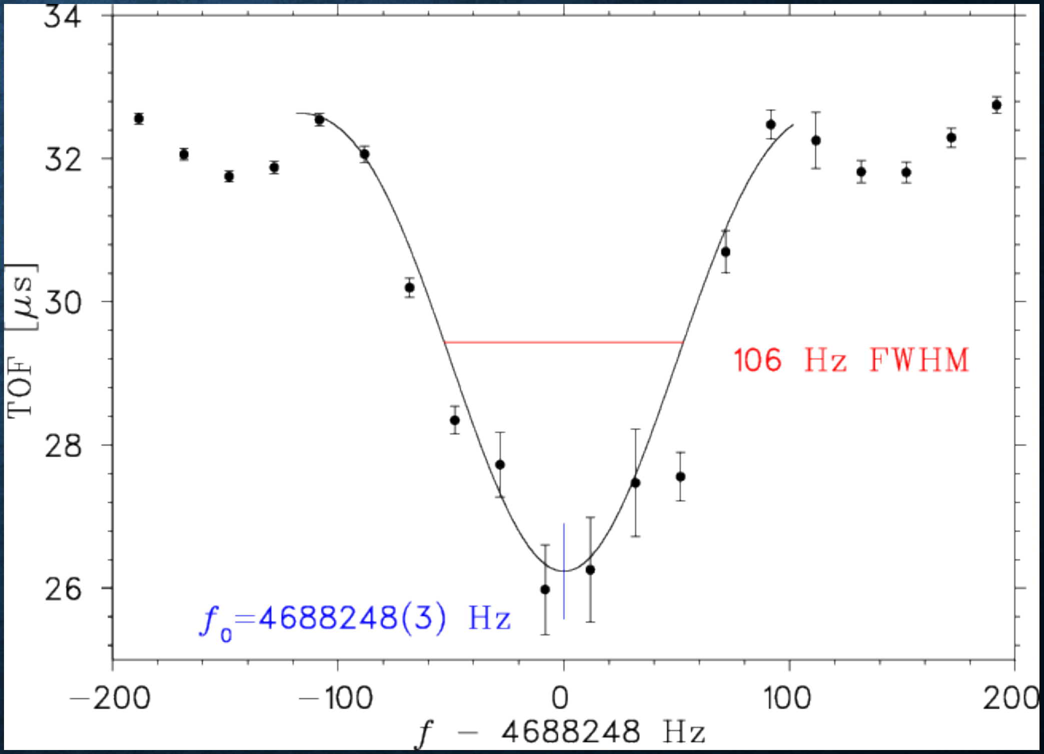
  ~4.6883MHz



REDUCED CYCLOTRON ω_+

- GOAL: At which frequency do we observe the ions being excited?

  4.688248 (3) MHz



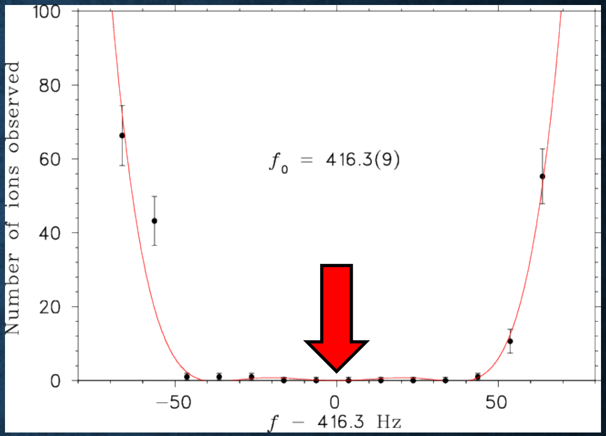
CYCLOTRON

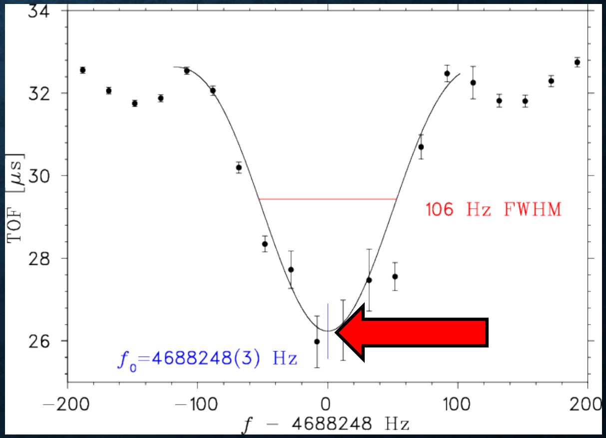
ω_C

Cyclotron Frequency

$\omega_- + \omega_+ = \omega_c$

$f_- + f_+ = f_c$





CYCLOTRON
ω_C

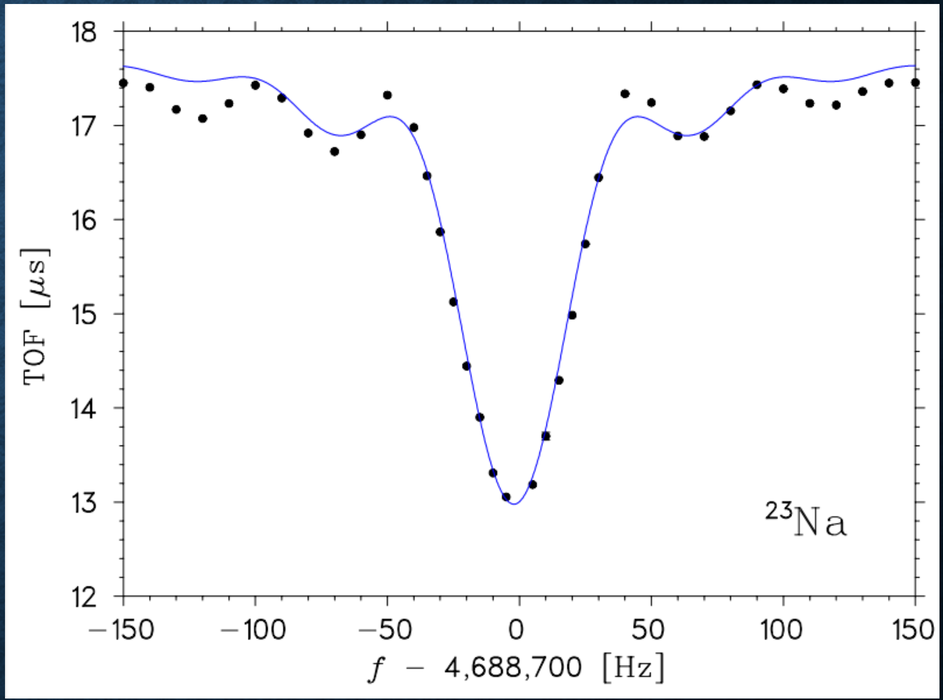
Cyclotron Frequency

$$\omega_- + \omega_+ = \omega_c$$

$$f_- + f_+ = f_c$$

$$m = \frac{q}{2\pi f_c} * B$$

B = 7.0193198 (4) T
(Etienne Gilg)



CONCLUSION

- Recovered the mass for ^{23}Na mass to be 21.41432 (12) GeV

  (0.00001% Error from accepted value)

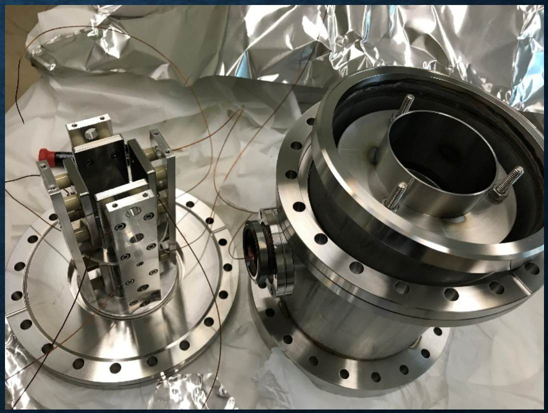
- Successfully installed a second ion source for the beamline

- Calibrated magnetic field to 7T (Etienne Gilg)

FUTURE WORK

- Try higher excitation times for higher resolutions of resonance width
- Continue to optimize the beamline to have a greater efficiency (ion count minute)
- Install a lens and seteerer to improve beam optics

Penning Trap not Online:	600 counts/min
Penning Trap Online: (with excitation)	100 counts/min



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