INSTALLING AND COMMISSIONING TAMUTRAP THROUGH MASS MEASUREMENT

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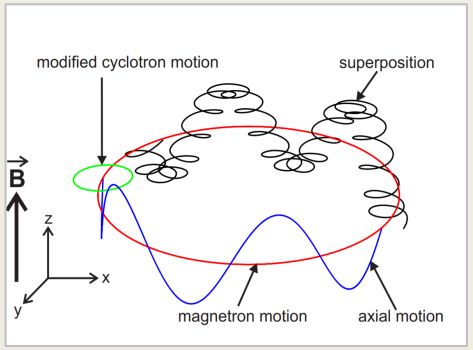
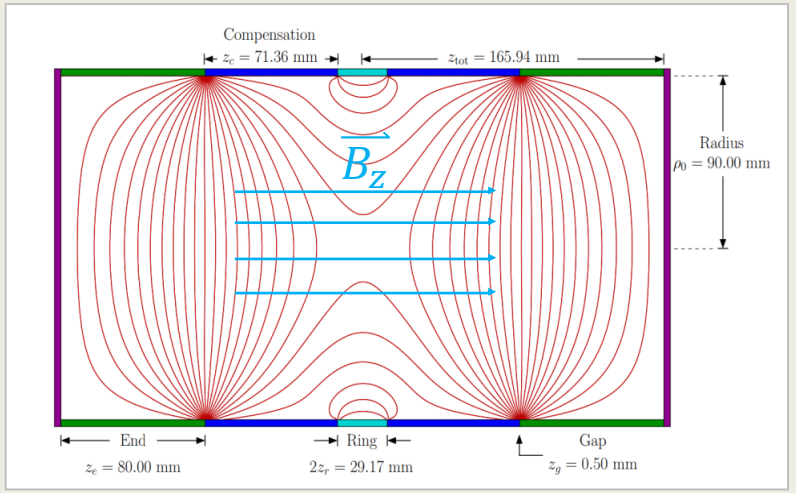
What is a Penning trap?

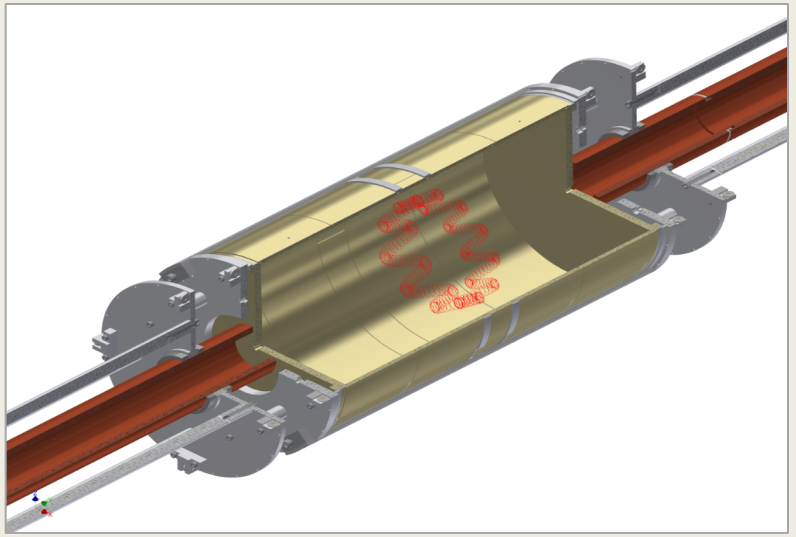
- Penning trap = ion trap which confines ions with a homogenous magnetic field and quadrupolar electric field
- Three characteristic frequencies occur in a penning trap
  - Reduced cyclotron- ω_+
  - Magnetron- ω_-
  - Axial- ω_z
- Pure cyclotron- ω_c

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

$$\omega_c = qB/m$$

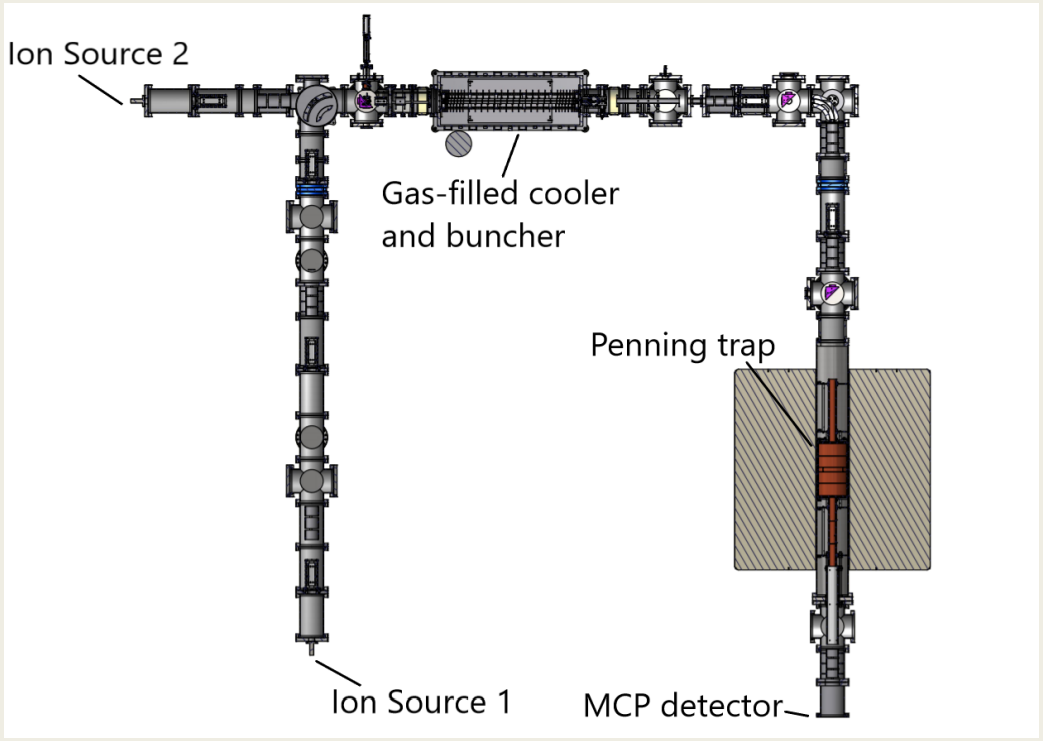


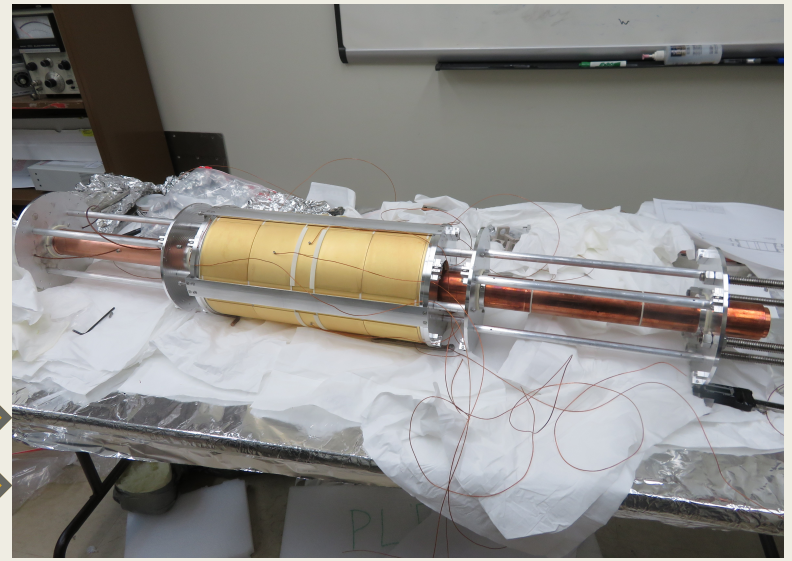




TAMUTRAP Installation

- Removed prototype trap
- World's largest Penning trap→ 180mm diameter

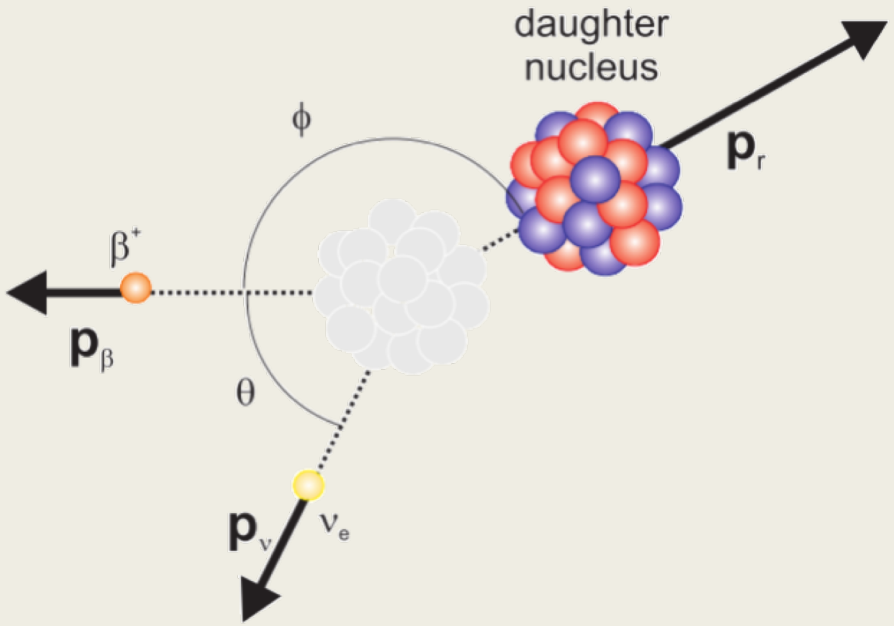


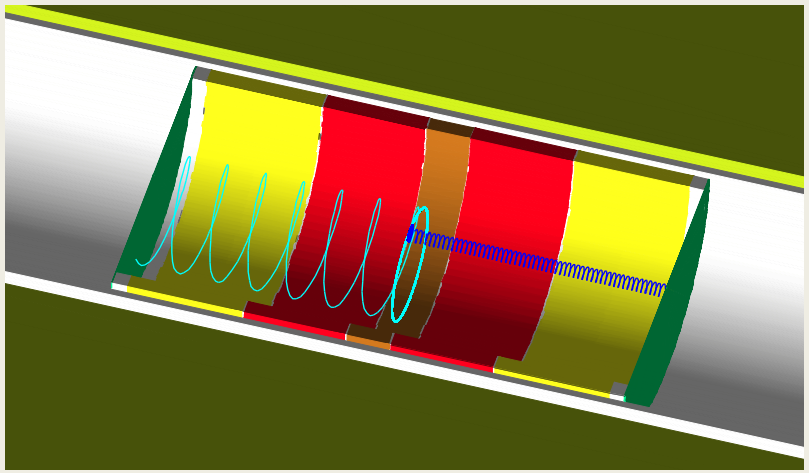


$a_{\beta\nu}$: The Angular Correlation Parameter

- Standard Model currently describes the weak interaction as V-A→ no scalar contribution
- TAMUTRAP will search for a scalar contribution in β-delayed proton decay
  - In SM, $a_{\beta\nu} = 1$
  - If $a_{\beta\nu}$ is measured to be less than 1, physics beyond SM has been discovered

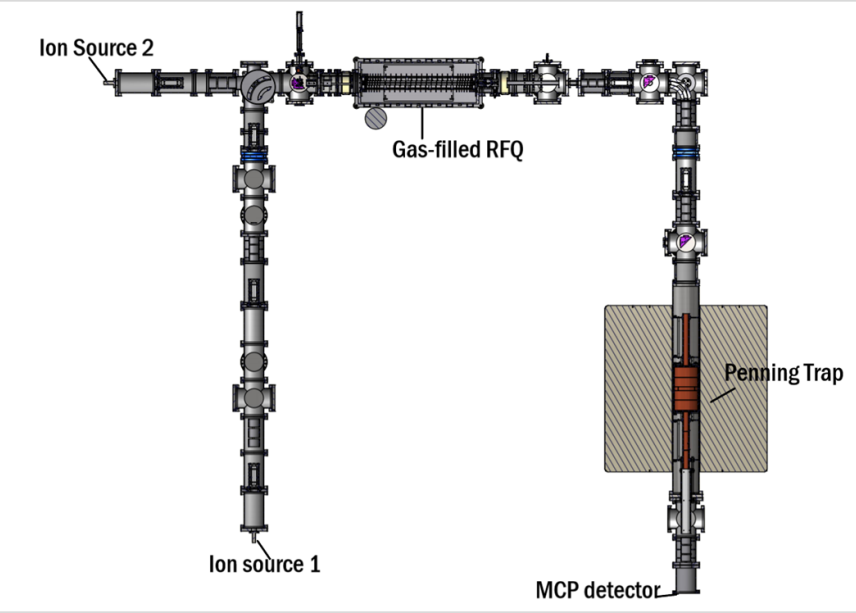
$$dW(\theta) \sim 1 + a_{\beta\nu}\frac{v_\beta}{c}cos\theta$$

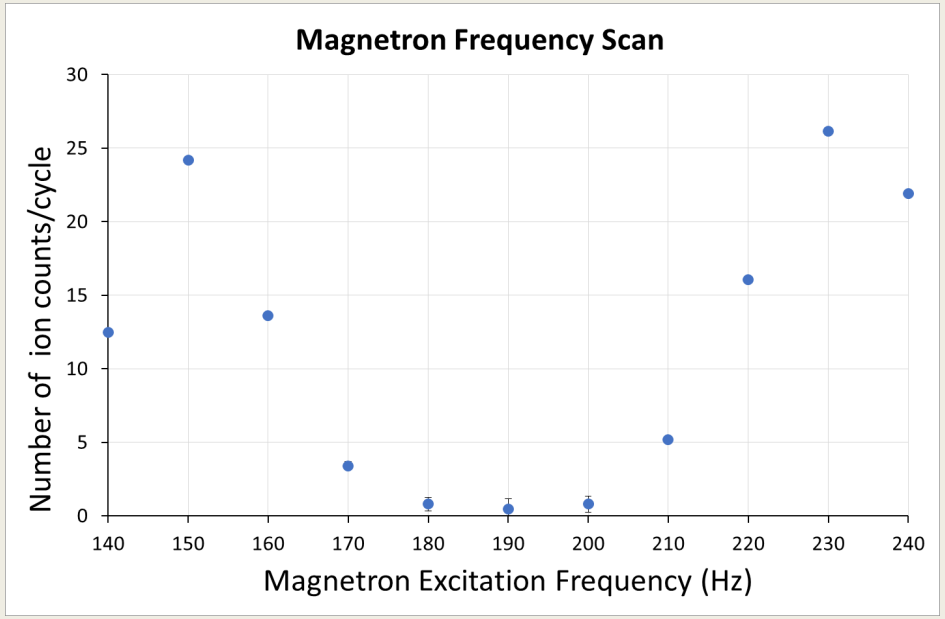


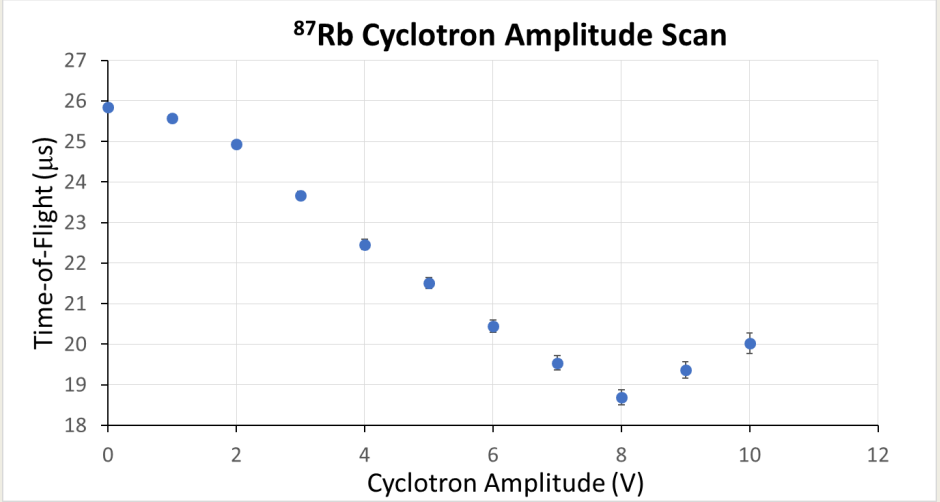


Experimental Method

- Optimize beamline for transmission
- Scan for the magnetron frequency
- Scan for and optimize cyclotron amplitude
- Time-of-flight ion cyclotron resonance technique

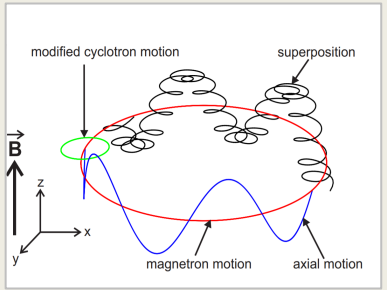


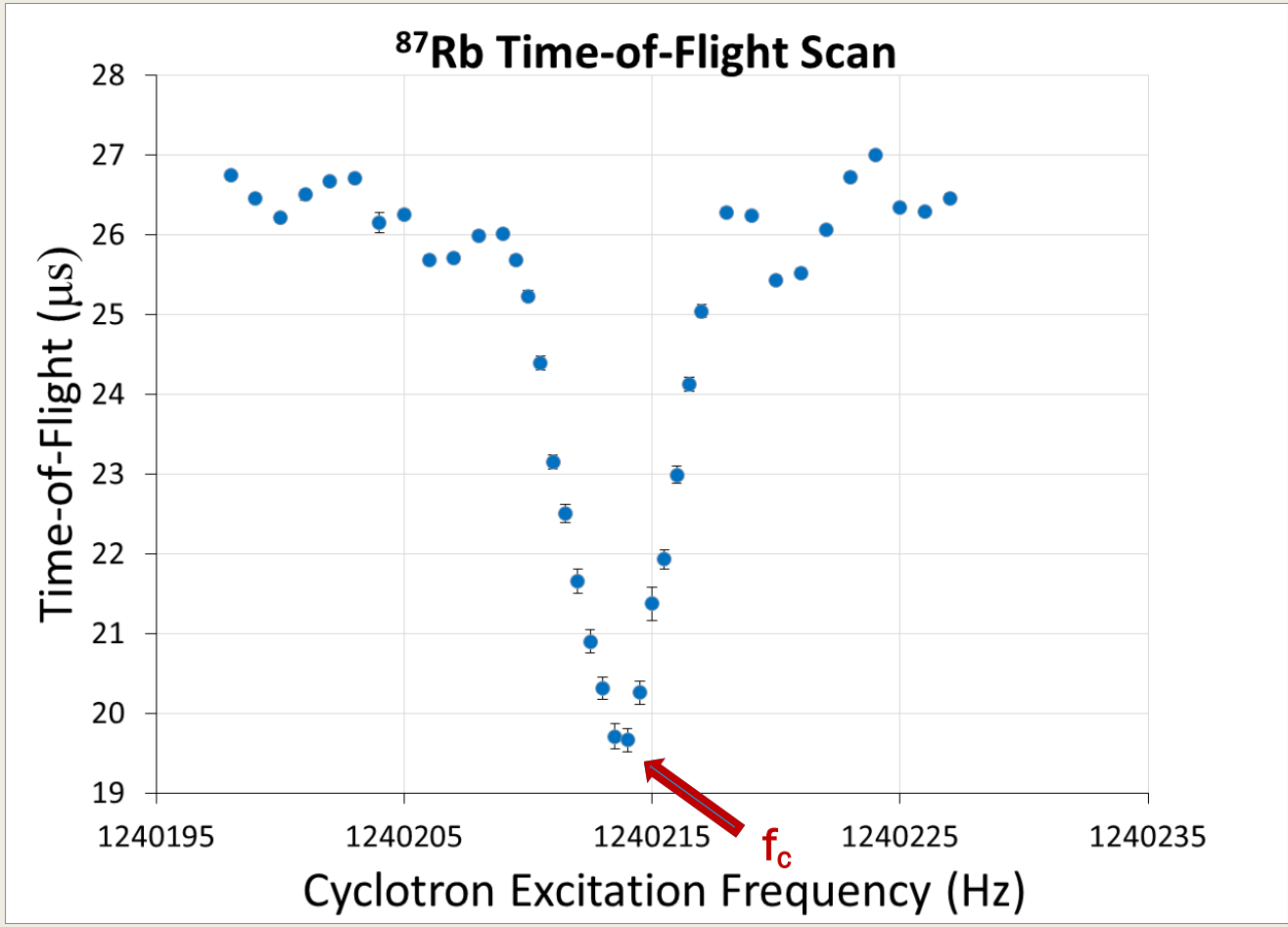




Time-of-Flight Ion Cyclotron Resonance

1. Confine ions in TAMUTRAP
2. Apply magnetron excitation→ increases radius
3. Apply ‘pure’ cyclotron excitation near f_c → couples radial frequencies, allows conversion
4. Eject ions from trap→ radial energy is converted to axial energy
5. Plot time-of-flight against excitation frequency to find f_c
6. Calculate mass : $M_x = \frac{f_{\mathrm{ref}}}{f_x}(M_{\mathrm{ref}} - m_e) + m_e$

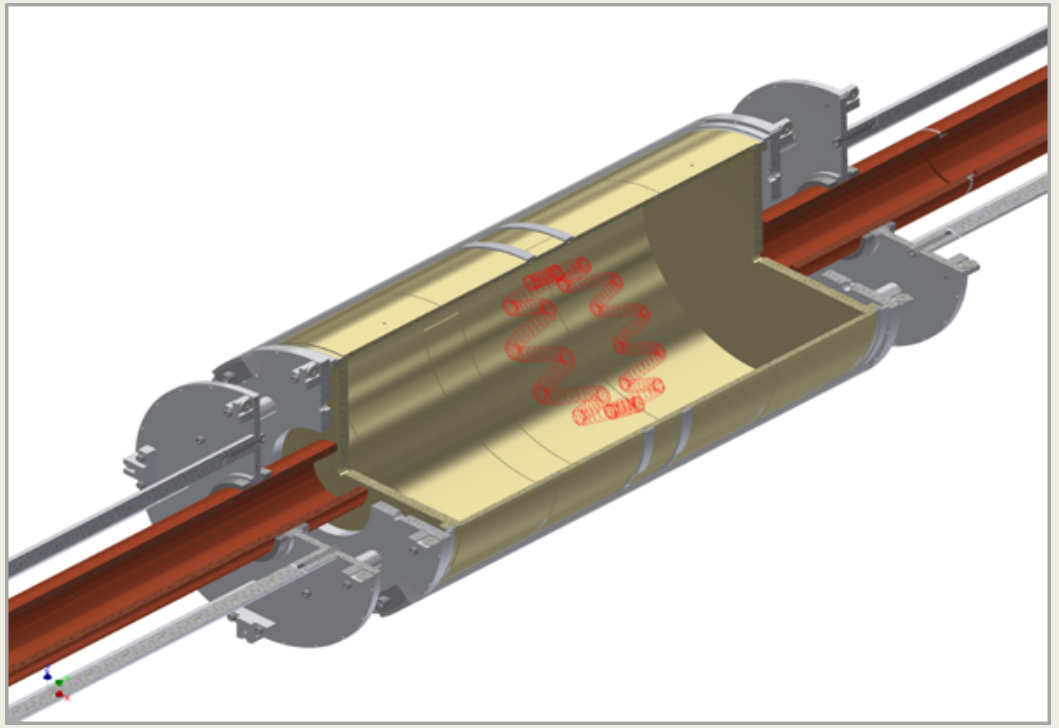




Isobaric Separation

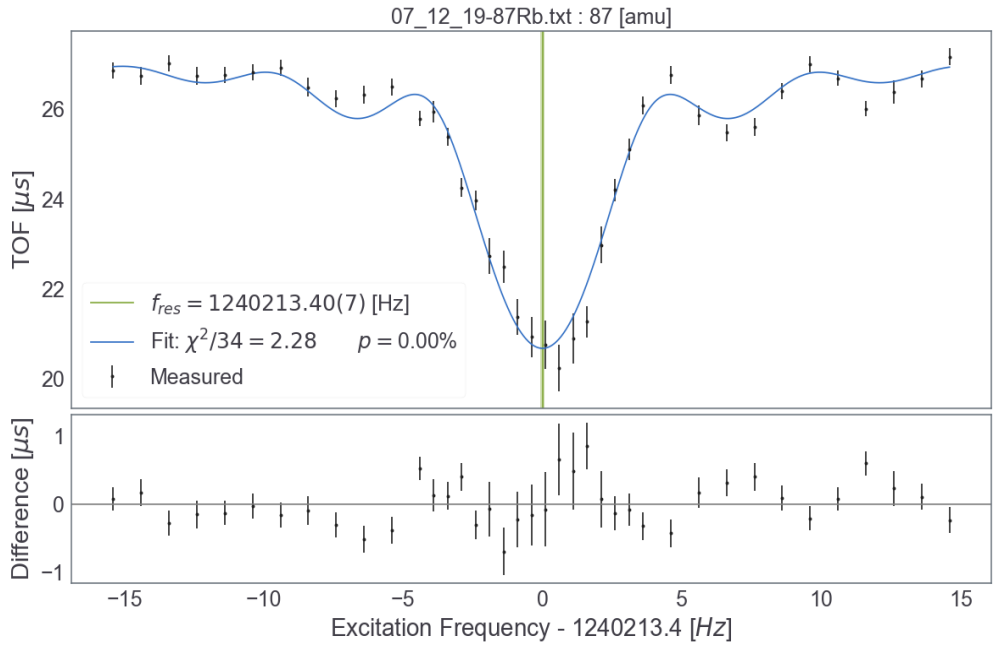
- Mass measurement and purification never combined in a single Penning trap before!
- Additional step in TOF technique:

1. Magnetron excitation
2. *ω_c excitation, which re-centers a certain mass*
3. 2^{nd} ω_c excitation to couple radial motions

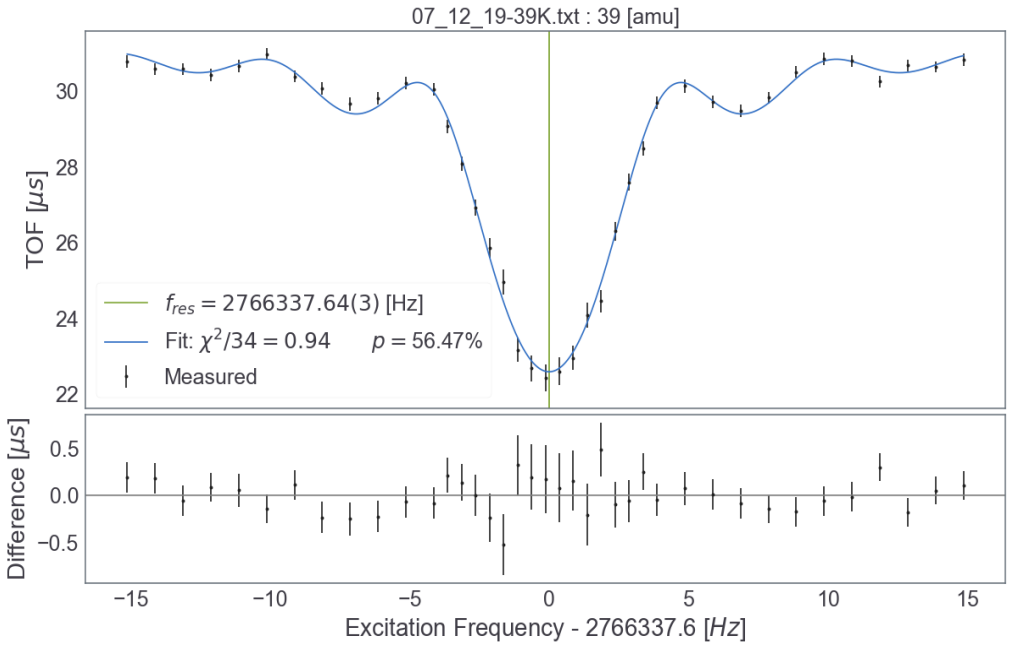


Cyclotron Resonance Frequency Comparison

^{87}Rb time-of-flight



^{39}K time-of-flight



Results and Conclusions

Isotope	Mass [amu]		Mass difference [keV]
	AME	This work	
^{23}Na	22.989 769 28	22.989 769 1(5)	0.2 ± 0.4
^{85}Rb	84.911 789 75	84.911 785(4)	4 ± 4
^{87}Rb	86.909 180 53	86.909 180(5)	0 ± 5
^{133}Cs	132.905 451 97	132.905 455(10)	3 ± 10

- All measured masses correct to within 80 parts per billion
- TAMUTRAP has demonstrated precision ion manipulation and is prepared for future beta decay experiment

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Questions?

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