Automation and Computation of TAMUTRAP

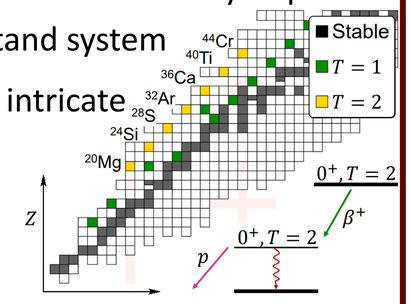
M. Nasser, V.E. Iacob, G. Chubarian, D.McClain, V.S. Kolhinen, D. Melconian, A. Ozmetin, B. Schroeder, P.D. Shidling

CENTER FOR EXCELLENCE
CENTAUR
IN NUCLEAR TRAINING AND UNIVERSITY-BASED RESEARCH

National Nuclear Security Administration

Motivation

- As we develop our program of beta-delayed-proton studies, we must understand system
- Automation allows more intricate methods and outcomes
- Minimizes systematics
- Improve $\Delta M/M$



Python Pulsing Software (P2S)

- FPGA had detrimentally noisy 2.5V TTL logic pulsing
- PulseBlaster Signal Controller providing 24 channels
- Clean, ns resolution, true 5V TTL pulses

Scan Automation System (SAS)

- Handles mass measurement scans
- Controls DAQ and function generator to perform scans across an arbitrary set of frequencies
- Can now easily perform numerous long or short scans to minimize drifts

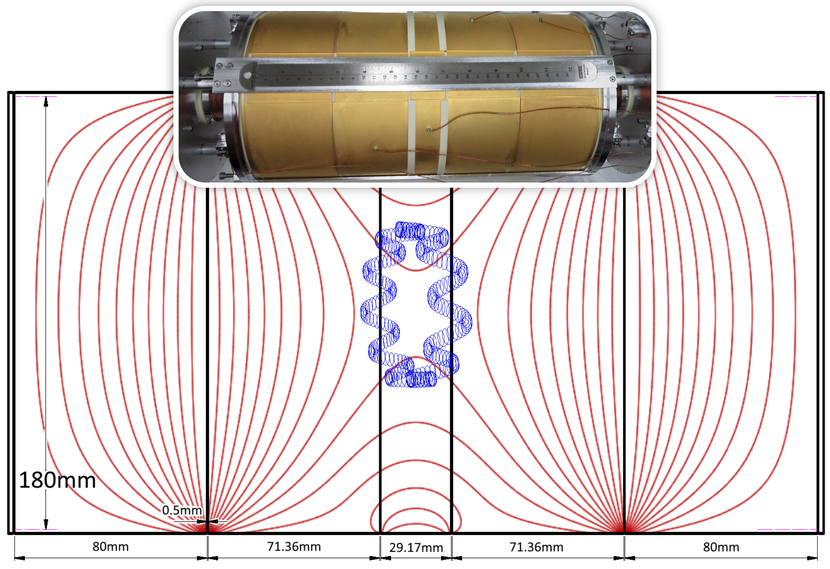
Trap Details

- 4.75 MeV proton & 7T field: 45 mm Larmour radius
- Length to radius ratio of 3.72 (canonical is 11.75)
- Better than 5 ppm magnetic field homogeneity

Penning Traps

- Penning traps center a quadratic electric potential
- Sits in a magnetic field to confine in the x-y plane
- 3 coupled eigenmotions: $\omega_c^2 = \omega_+^2 + \omega_-^2 + \omega_z^2$
- Segmented electrodes allow RF excitation to either radially shift trajectories or control eigenmotions

WORLD'S LARGEST

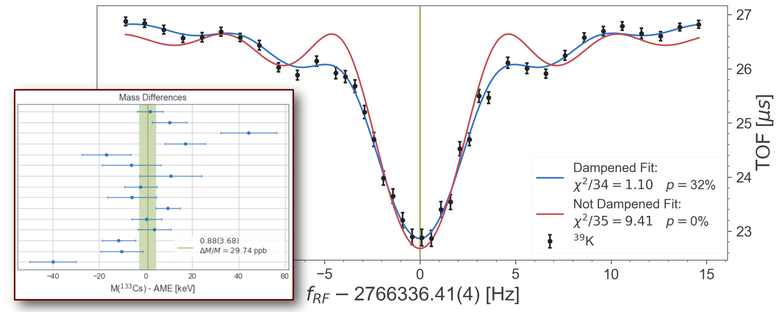


TOF Fitter and Integrator (TOFFI)

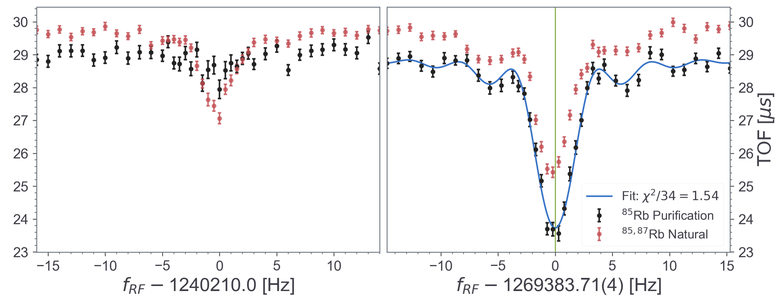
- Wanted to move away from standard approximation
- Now we fit against a full integration throughout the field and more using $T = \int_{z_0}^{z_f} \sqrt{\frac{m/2}{E_0 - qU(z) - \mu(\omega)B(z)}}\, dz$
- Magnetic moment is proportional to the radial energy through $\mu(\omega) \propto \rho_+^2 + (\rho_-^2 - \rho_+^2)\left(\frac{\pi}{2}\right)^2 \mathrm{sinc}^2[\phi(\omega, t_{ex})]$
- Dampening added to model for better representation

Mass Measurements and Dampening

- Fit spectra with TOFFI and get resonant frequencies and get mass differences $\omega = \frac{qB}{m} \implies m \sim m_r \frac{\omega_r}{\omega}$



- Can run as both purification and measurement trap



Conclusions

- Properly understand and able to manipulate ion motion for measurements/separation/etc.
- Successfully performed commissioning mass measurements for ^{23}Na, ^{85,87}Rb, ^{133}Cs
- Correct form for dampening achieved, thus improving fitting and mass measurements

Supported by U.S. Department of Energy Grants
DEFG02-93ER40773 and DE-NA0003841