TAMUTRAP: The World's Largest Penning Trap

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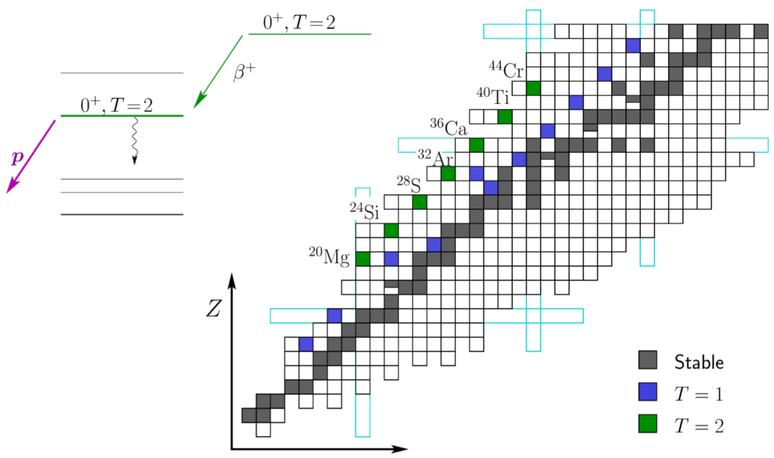
Motivation

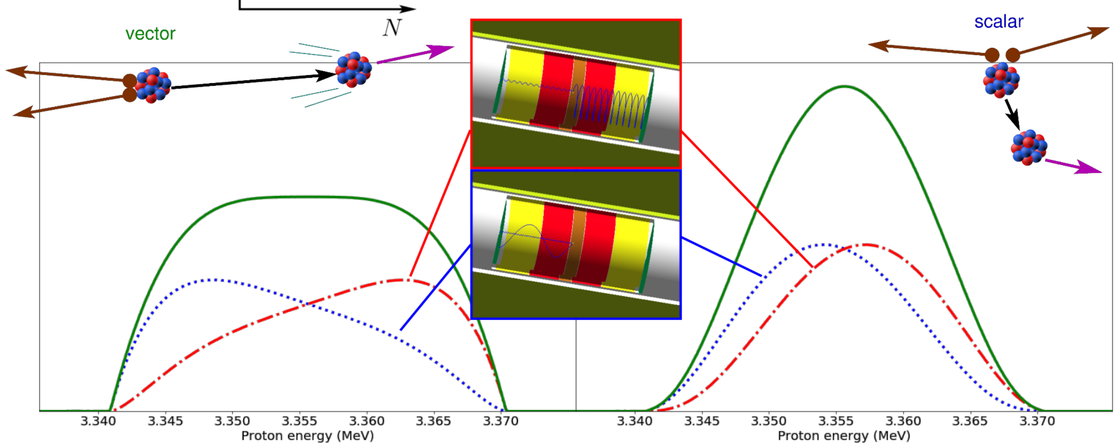
- The Standard Model (SM)works really well in most cases!
  - …not so well in other cases: need new physics
- SM neutrinos couple to leptons chirally: V-A
- If there is new physics in weak interaction, could manifest as V+A, scalar, pseudo-scalar, tensor
  - Our experiment will look for scalar
- For pure Fermi decays, β decay angular distribution is:

$$\Gamma(\theta) \sim 1 + a_{\beta\nu}\frac{p_e}{E_e} + b\frac{m_e}{E_e},$$

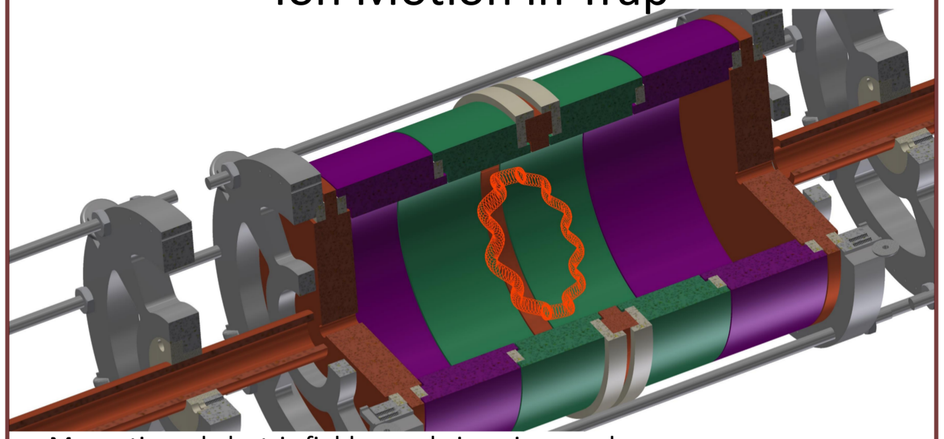
where $a_{\beta\nu} = 1$ for a purely vector interaction

- Neutrinos are really hard to detect! How can we get $\theta_{\beta\nu}$?
  - Our approach: measure recoiling nucleus by way of an emitted proton



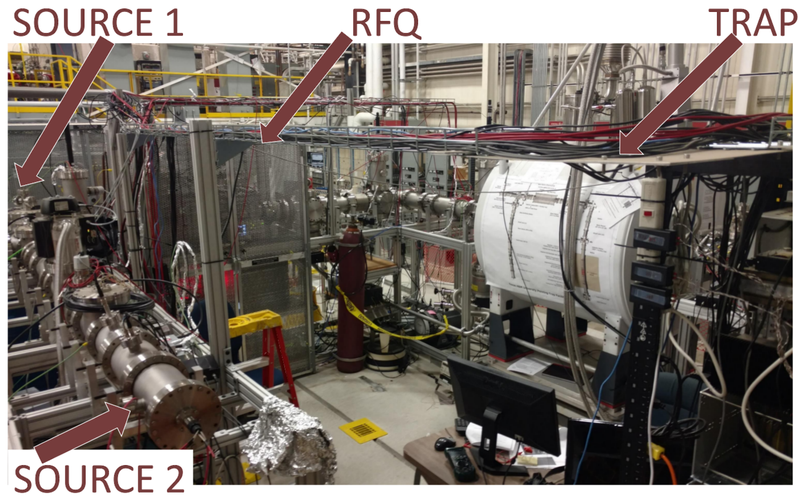


Ion Motion in Trap



- Magnetic and electric fields couple ion eigenmodes
- Radioactive ions can be excited away from the beam axis so that no βs are lost through the injection/extraction holes

- Monoenergetic proton Larmor radius is fixed in a uniform magnetic field
  - Novel Penning trap design with large radius and small length allows us to measure both β and proton energies
- Previous measurement has been made at 0.5% level only capturing the proton spectrum—our experiment is designed for <0.1% level
- Using same/opposite hemisphere data, we can reduce the problem to comparing the means of the two distributions (same and opposite direction) vs. the 2nd moment of one



90 mm Prototype Trap

- Using Penning trap so beta decay occurs at rest
  - 7 Tesla magnetic field confines radially
  - Electric field confines axially
- Half scale trap first trapping August 2016
  - Unique open geometry design with large radius: M. Mehlman, *NIMA* **712** (2013)
  - Half-scale is still largest Penning trap in the world.
- Making mass measurements since July 2017
- See Morgan's poster for more details!

Detectors

- Silicon detectors will act as the endcap electrodes of the trap to fully stop protons up to 4 MeV (>350 µm) and to get dE tag on positrons
- Large area to cover (5 mm ID to 180 mm OD)
- Energy resolution is crucial to meet measurement target
- Nab detectors have 3 keV FWHM so this is our target
- Including possibility for a telescope detector to better discriminate protons from positrons

Ongoing Work

- Installing full size trap this autumn
- Simulations being run to determine optimal design parameters for detectors
- K150 will provide rare isotope beam once constructed

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