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, $\beta$ decay angular distribution is:
  \[ \Gamma(\theta) \sim 1 + a_{PV} \frac{p_{\pi}^2}{E_{\pi}} + b \frac{m_{\pi}}{E_{\pi}}, \]
  where $a_{PV} = 1$ for a purely vector interaction
- Neutrinos are really hard to detect! How can we get $\theta_{PV}$?
- 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 $\beta$s are lost through the injection/extraction holes

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