β Decay Simulations in TAMUTRAP

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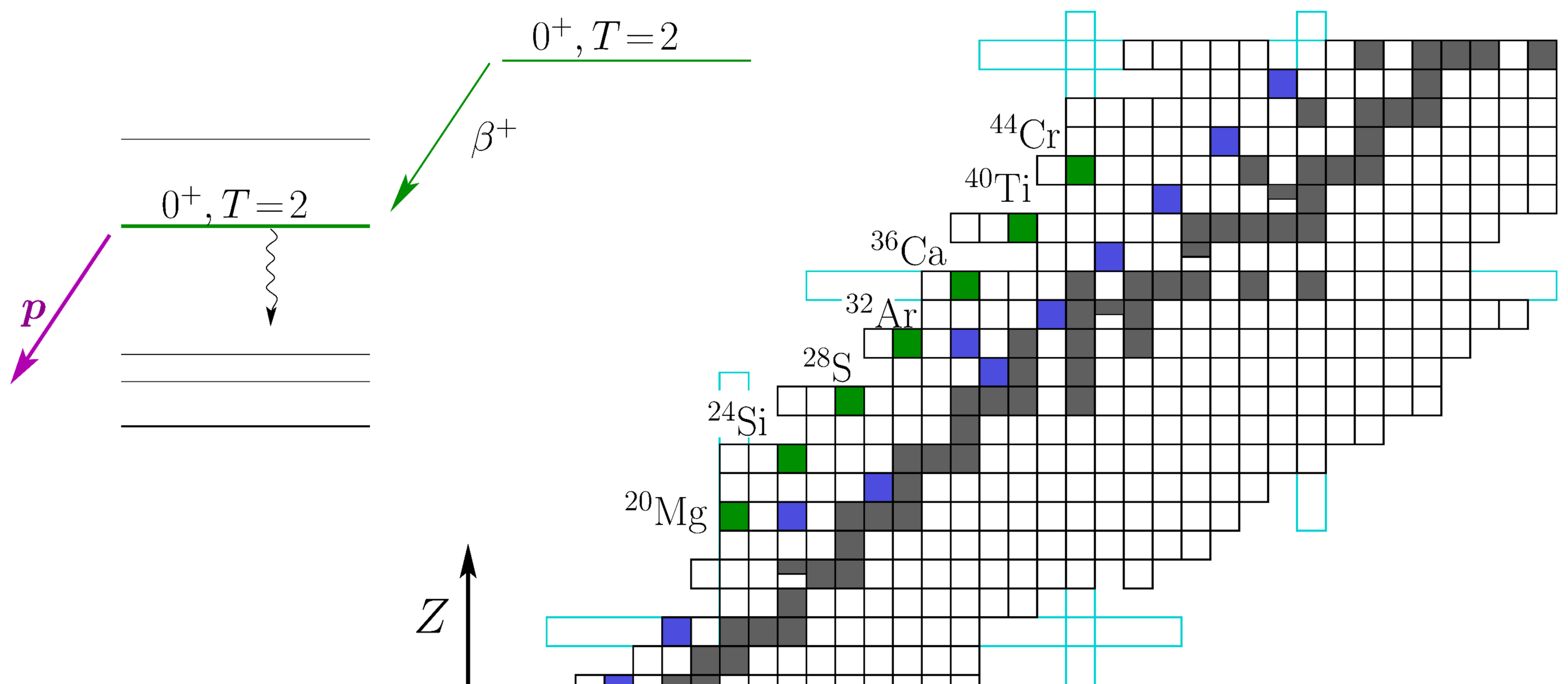
Motivation

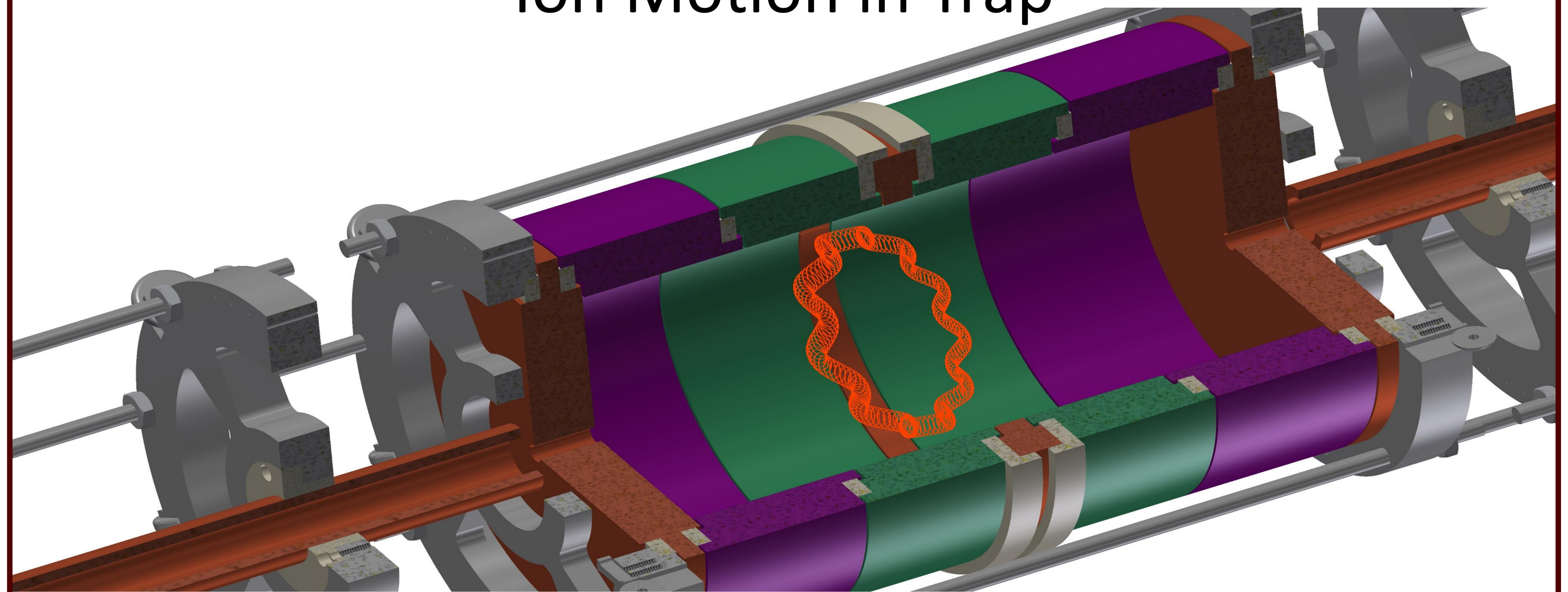
- The Standard Model passes tests fantastically in most cases!
  - …not so well in other cases: needs to be new physics somewhere
- SM neutrinos couple to leptons chirally: $V - A$
- If there is new physics in weak interaction, could manifest as Lorentz bilinear currents: $V + A$, scalar, pseudo-scalar, tensor
  - Our experiment will look for scalar
- For pure Fermi decays, differential β decay rate is:

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

where $\boldsymbol{a_{\beta\nu}} = 1$, $\boldsymbol{b} = 0$ 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



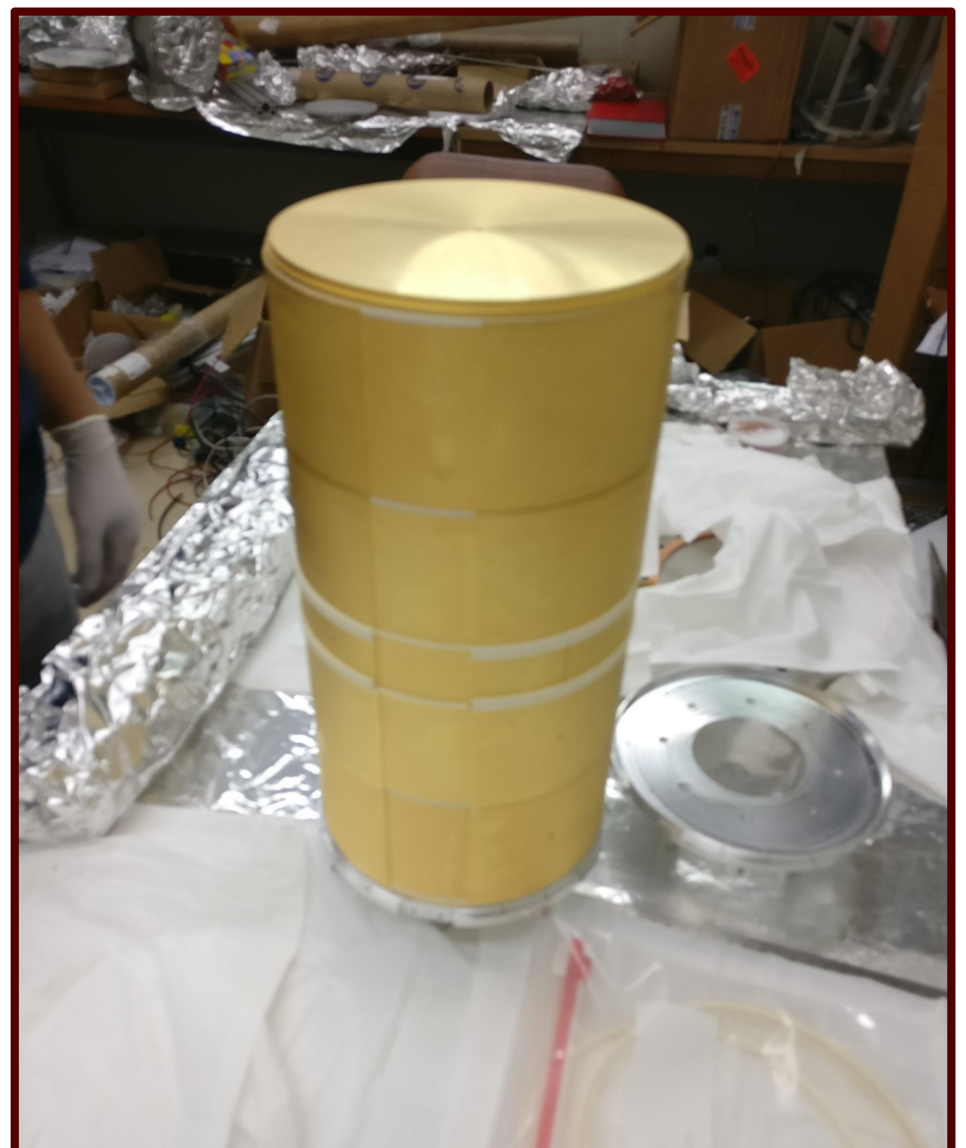
Ion Motion in Trap



- Magnetic and electric fields couple ion eigenmodes (shown not to scale)
- Radioactive ions can be excited away from the beam axis so that no βs are lost through the injection/extraction holes

World's Largest Penning Trap

- 7 Tesla magnetic field confines radially
- Electric field confines axially
- Full size trap installed and trapping June 2019
- Unique open geometry design with large radius (M. Mehlman, *NIMA* **712** (2013))



- 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 (E.G. Adelberger et al., *Phys. Rev. Lett.* **83** (1999))
  - Our target is <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