Cyclotron Radiation Emission Spectroscopy in a Penning Trap

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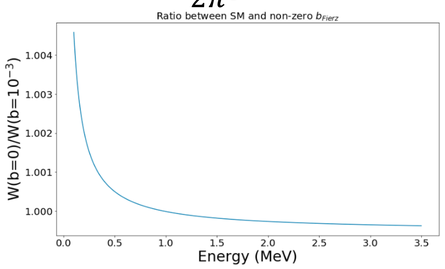
Motivation

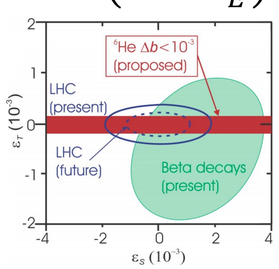
- Use Cyclotron Radiation Emission Spectroscopy (CRES) to reconstruct the beta decay spectrum of ^{6}He to measure the Fierz parameter.
- Check the validity of this experiment in a Penning trap and the accommodations that must be made to incorporate the Penning trap into the experiment.

Fierz Parameter

- In Standard Model Physics the Fierz term, $b = 0$.
- A non-zero b would lead to non-zero contributions of scalar or tensor couplings which is beyond the Standard Model.

$$WdE \propto \frac{F(\pm Z,E)}{2\pi^3} pE(E_0 - E)^2 dE\xi\left(1 + b\frac{m}{E}\right)$$



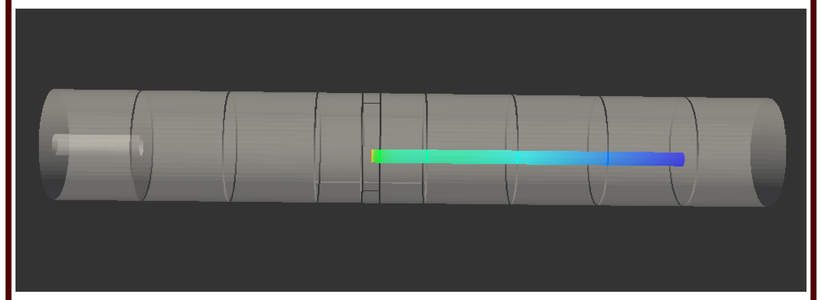


Cyclotron Radiation Emission Spectroscopy

- Measure the emitted cyclotron radiation from a beta particle as it travels through a constant magnetic field.
- Reconstructs the starting kinetic energy from the cyclotron frequency.

$$f = \frac{qB}{2\pi(m + E)}$$

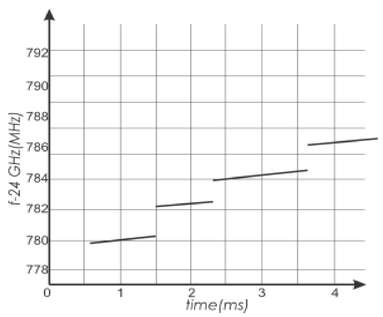
Kassiopeia



Simulated Penning trap with a single electron track showing the loss of energy due to cyclotron radiation

Optimization of Kassiopeia

- Kassiopeia had extremely long computation times which had to be lowered.
- Compared to Project8 experiment to ensure the simulation remained physical



Frequency measured from a CRES event.

Beta Decay Spectrum

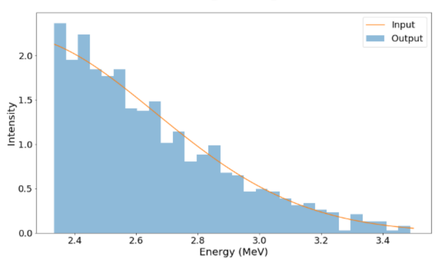
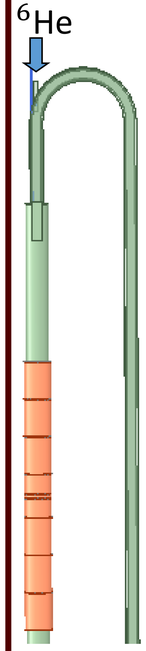
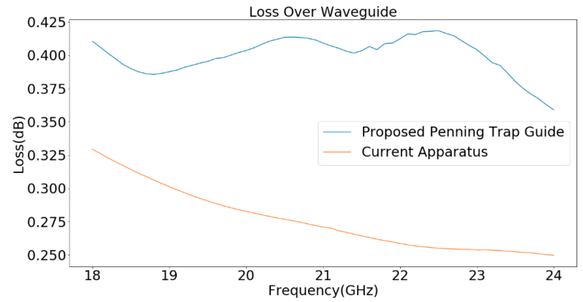


Fig.4 Beta decay spectrum created from an initial cyclotron frequency.

HFSS



- High Frequency Structure Simulator is used to measure the power loss over the wave-guide.
- Applied a mesh to the bend in the guide to allow a beam to enter the trap.
- Loss needs to be below 1 dB.



Loss of current guide compared to updated guide.

Conclusions and Future Work

- Successfully implemented a Penning trap into Kassiopeia and drastically reduced computation time per event.
- Was able to use the CRES technique to reconstruct the beta decay spectrum of ^{6}He .
- Showed in HFSS that the loss from the mesh and trap is acceptable for the experiment.
- Begin development of Penning Trap.

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