R&D for a neutrino mass experiment

PROJECT 8

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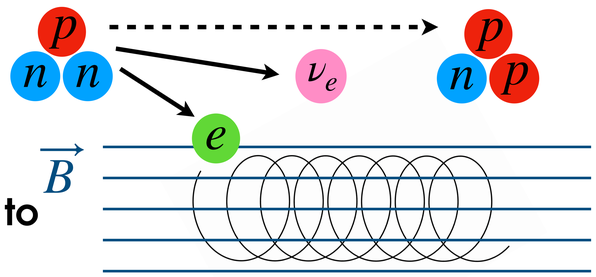
Measuring neutrino mass using spiraling electrons

Molecular tritium beta decays into a uniform B-field. The emitted electron undergoes cyclotron motion and emits EM radiation. Measure *f* -> convert to *E* -> derive spectrum.



$$\omega = \frac{eB}{m_e + E_{kin}/c^2}$$

The distortion of the energy spectrum near the endpoint constrains the neutrino mass

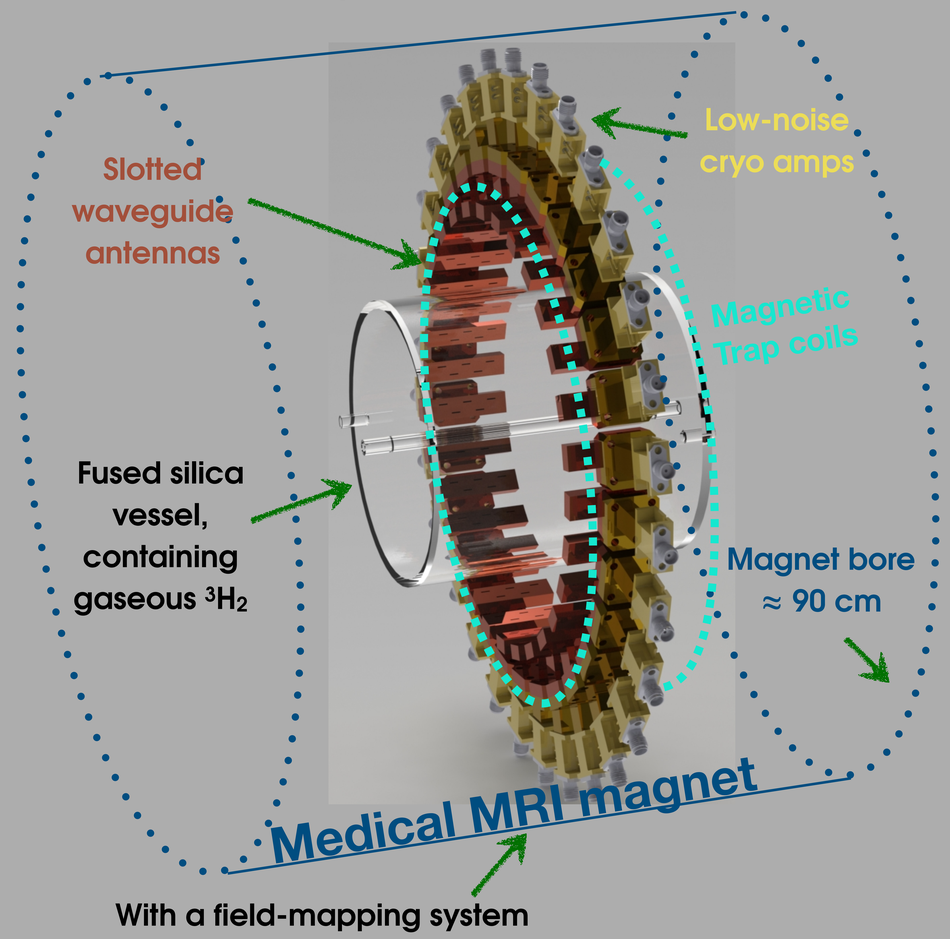
Experimental goals & design

- Main goal: demonstrate the technique in a free-space volume, in a way that is scalable to larger volumes
  - Total efficiency: 10%
  - Effective volume: 100 cm^3
  - Tritium source at > 30 K, antennas at < 10 K
  - Optimized magnetic trap / antenna array configuration
- Target neutrino mass sensitivity: ≤ 2 eV/c^2

See other P8 posters for results, sensitivity, and future phases

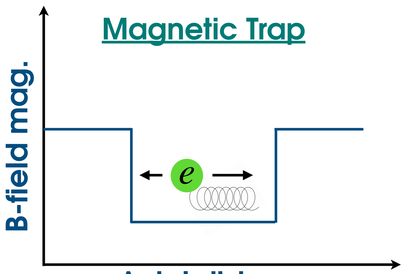
The detector:

(the Phase III Free-space CRES demonstrator)



Detection Method

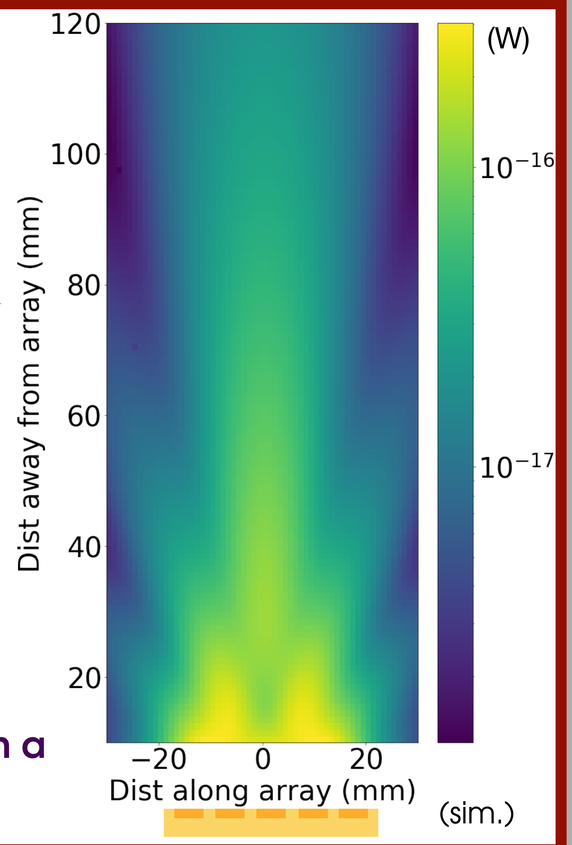
- Electrons are trapped magnetically, bouncing in an axial trap for sufficiently long observation times
  - B-field ~ 1 T, freq. ~ 26 GHz
  - Electrons with pitch angle (angle btwn momentum and B-field) within 5˚-7˚ of 90˚ are trapped
- Slotted-waveguide antennas measure emitted power



Particle & Antenna Simulations

RF industry design tools and in-house particle tracking, receiver, and signal processing packages are used to optimize the tightly coupled field-antenna-trap system.

Right: Antenna near-field radiation pattern mapped with a pitch-angle = 90˚ electron as source



The P8 Collab.

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Neutrino conference: June 2020